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# DICTIONARY

OF

# CHEMICALS AND RAW PRODUCTS

USED IN THE MANUFACTURE OF

# PAINTS, COLOURS, VARNISHES AND ALLIED PREPARATIONS

THE ABERDEEN UNIVERSITY PRESS LIMITED

# DICTIONARY
OF
# CHEMICALS AND RAW PRODUCTS
USED IN THE MANUFACTURE OF
# PAINTS, COLOURS, VARNISHES AND ALLIED PREPARATIONS

BY

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# PREFACE.

THE need of a book of reference giving brief descriptions of the various chemicals and other substances which are employed in the paint, colour and varnish trades has been expressed to me by many correspondents. In the following pages I have endeavoured to satisfy that need with, I hope, some small measure of success. As regards the methods of manufacture of pigments like white lead, vermilion, chrome yellow, Prussian blue, etc., I have only briefly referred to them, and for fuller details I would refer readers to my *Manual of Painters' Colours, Oils and Varnishes*, in which they will find them fully described. In my book on *Soaps* will be found an extended account of the chemistry of oils, and a full account of the methods of extraction, and to this book reference may usefully be made. Although the coal tar colours have come to the front of late years for the preparation of lake pigments, only a brief reference to them has been made; their number is now so great that it was quite impossible to note them in detail. Any one interested in them will find a detailed account in my *Dictionary of Coal Tar Colours.*

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*March*, 1901.

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# A.

**ACCROIDES.**—See *Gum Accroides.*

**ACETATES.**—A series of compounds derived from acetic acid by combination with metallic or other bases. Many acetates are valuable industrial compounds. They are generally soluble in water; a few containing basic oxides, such as those of copper and iron, are insoluble in water. When heated with dilute sulphuric acid they are decomposed and acetic acid is given off, with the formation of a sulphate of the base. The following acetates are those most used in the colour industry:—

**ACETATE OF AMMONIA.**—The normal salt has the formula $NH_4C_2H_3O_2$; it is mostly sold in the form of a solution in water, and is conveniently made by mixing the ordinary liquor ammonia with acetic acid. If glacial acetic acid be employed with the strong liquor ammonia, about equal volumes are required; a solution of acetate of ammonia so prepared has a specific gravity of 1·110.

Acetate of ammonia may be obtained in the solid state, but as acetate of ammonia on heating readily passes into acetamide, $C_2H_3ONH_2$, the solid often contains that product. Acetate of ammonia is easily soluble in alcohol. The commercial article may be adulterated by addition of chloride or carbonate or sulphate of ammonia. These may be readily detected by the ordinary tests for chlorides, carbonates or sulphates. Acetate of ammonia should completely volatilise on heating.

The proportion of real acetate of ammonia in a commercial product is best ascertained by determining both the acetic acid and ammonia by distillation with sulphuric acid and with caustic soda, as described under *Acetic Acid* and *Ammonia*.

**ACETATES OF LEAD.**—Lead combines with acetic acid to form one normal and four basic acetates.

**Normal Lead Acetate** has the formula, $Pb2C_2H_3O_2$; when pure it forms pearly white crystals, is readily soluble in water, and has a sweet taste; hence this body is often known as "sugar of lead". Acetate of lead is commercially sold in two forms, "brown sugar of lead" and "white sugar of lead"; the former is made from the crude pyroligneous acid obtained in the distillation of wood, the latter from ordinary acetic acid; this of course is the purest form, the brown containing some organic impurities. The crystalline salt contains three molecules of water of crystallisation.

Lead acetate dissolves in one and a half times its weight of cold water and in half its weight of hot water. The following table gives the strength of various solutions of lead acetate:—

STRENGTH OF SOLUTIONS OF LEAD ACETATE AT 15° C.

| Specific Gravity. | Per Cent. of Salt. | Specific Gravity. | Per Cent. of Salt. | Specific Gravity. | Per Cent. of Salt. |
|---|---|---|---|---|---|
| 1·0070 | 1 | 1·0505 | 7 | 1·1221 | 16 |
| 1·0140 | 2 | 1·0580 | 8 | 1·1330 | 16 |
| 1·0211 | 3 | 1·0655 | 9 | 1·1560 | 20 |
| 1·0283 | 4 | 1·0731 | 10 | 1·1740 | 22 |
| 1·0366 | 5 | 1·0891 | 12 | 1·1928 | 24 |
| 1·0430 | 6 | 1·1055 | 14 | | |

When heated to 280° C. it melts; at slightly higher temperatures it decomposes, giving off acetone and leaving behind a basic oxide. When solutions of lead acetate and litharge are boiled together, the latter is dissolved, and solutions of basic acetates are obtained. These basic acetates may be regarded as compounds of the normal acetate with either lead oxide, PbO, or with the hydroxide, $PbH_2O_2$. Several are known, of which the following are the most important:—

**Dibasic Acetate of Lead,** $Pb2C_2H_3O_2$, $PbH_2O_2$, can be obtained by boiling 22½ parts of litharge in a solution of 38 parts of normal lead acetate.

**Tribasic Acetate of Lead,** $Pb2C_2H_3O_2$, $2PbH_2O_2$, is obtained by boiling 7 parts of litharge in a solution of 6 parts of normal lead acetate. This basic acetate is sometimes known as the sub-acetate, also as Goulard's extract, and it is employed in pharmacy.

**Sesquibasic Acetate of Lead,** $2(Pb2C_2H_3O_2)$, $PbH_2O_2$, is obtained by heating the normal acetate.

All these basic acetates are readily soluble in water.

These solutions have an alkaline reaction. When a current of carbonic acid gas is passed through them they yield a precipitate of lead carbonate, more or less basic in character, and leave a solution of the normal acetate. This property of giving a precipitate with carbonic acid distinguishes them from the normal acetate, which does not give one, or at most but a slight one. This property of the basic acetates has been taken advantage of in the preparation of white lead. The basic acetate is made by boiling litharge in a solution of the normal acetate, then the product is treated with carbonic acid gas, the white lead thrown down and the normal acetate regenerated and used over again. Many processes based on this reaction will be found described in the author's *Manual of Painters' Colours.*

Acetates of lead may be assayed in the manner recommended by Fresenius. Ten grammes of the sample are dissolved in water in a 500 c.c. flask ; 60 c.c. of normal sulphuric acid are then added and the flask filled up with water to the mark, an extra 1·3 c.c. being added to allow for the volume occupied by the precipitate of lead sulphate. After shaking the flask the precipitate is allowed to settle : 100 c.c. of the clear liquid is taken, boiled and precipitated with barium chloride ; the barium sulphate formed is collected, washed, dried, ignited and weighed. Its weight multiplied by 0·4206 is subtracted from 0·588, which is the weight of normal sulphuric acid added to each 100 c.c. of the solution. The remainder multiplied by 113·7 gives the percentage of PbO in the sample. Another 100 c.c. are then drawn off and titrated with normal soda, using litmus as an indicator. Multiply the number of c.c. of alkali used by 0·06, and subtract from this the previously obtained weight of barium sulphate multiplied by 0·515 ; the remainder multiplied by 50 will be the percentage of acetic acid in the sample.

In the case of the basic acetates, the quantity of lead oxide present in the basic form may be ascertained by precipitating with carbonic acid gas, collecting the precipitate, washing, drying and igniting until the residue is of a bright yellow colour, then weighing. This gives the quantity of lead oxide, PbO, in the sample.

**ACETATE OF SODA.**—$NaC_2H_3O_2$ occurs in crystals containing three molecules of water of crystallisation. It is soluble in 2½ its weight of cold water and about half its weight of hot water. It is used only to a limited extent in colour making.

**ACETIC ACID.**—$HC_2H_3O_2$, or $CH_3COOH$. This is a most important acid; it occurs naturally in the juice of many plants, either in the free condition, or as calcium, or potassium acetate; it also occurs in the form of organic acetates in the essential oils of many fruits. It is obtained as a chief product in the distillation of wood, the crude acid being known as pyroligneous acid; it is also formed during the acetous fermentation of wines, or other liquids containing alcohol, from which it may also be obtained by oxidation processes. Pure acetic acid is usually obtained by the distillation of sodium acetate with sulphuric acid; for preparing the commoner qualities grey calcium acetate is employed.

Acetic acid is sold in several qualities. 1. Liquid of 1·035 (7° Tw.) specific gravity, and containing 25 per cent. of acetic acid. 2. Liquid of 1·0523 (10·4° Tw.) specific gravity, containing 40 per cent. of acetic acid. 3. Acetic acid of the *British Pharmacopœia;* this has a specific gravity of 1·044 (9° Tw.), and contains 33 per cent of acetic acid. 4. Glacial acetic acid, a liquid having a pungent, acid odour, a specific gravity of 1·058 (11·6° Tw.), and containing 98·8 per cent of acetic acid. This variety, when cooled down, crystallises in large, clear, colourless crystals which do not melt until the temperature reaches above 60° F. (15·5° C.). It is from this peculiarity of crystallising that this variety derives its name of glacial. Besides these varieties of acetic acid, which are really more or less dilute solutions of the real acid in water, there are the cruder varieties, such as "wood acid," "pyroligneous acid," which are occasionally sold.

Acetic acid is a liquid having a strong acid odour and sharp taste; it mixes freely with water in all proportions and, if the acid be pure, its strength can easily be ascertained by a determination of the specific gravity of its solution in water. Oudemans has constructed the following table of specific gravities of aqueous solutions of acetic acid at 15° C. (60° F.):—

## SPECIFIC GRAVITY OF ACETIC ACID SOLUTIONS.

| Specific Gravity. | Degrees Twaddell. | Per Cent. $HC_2H_3O_2$. | Specific Gravity. | Degrees Twaddell. | Per Cent. $HC_2H_3O_2$. |
|---|---|---|---|---|---|
| 1·0007 | 0·14 | 1 | 1·0623 | 12·46 | 51 |
| 1·0022 | 0·44 | 2 | 1·0631 | 12·62 | 52 |
| 1·0037 | 0·74 | 3 | 1·0638 | 12·76 | 53 |
| 1·0052 | 1·04 | 4 | 1·0646 | 12·92 | 54 |
| 1·0067 | 1·34 | 5 | 1·0653 | 13·06 | 55 |
| 1·0083 | 1·66 | 6 | 1·0660 | 13·20 | 56 |
| 1·0098 | 1·96 | 7 | 1·0666 | 13·32 | 57 |
| 1·0113 | 2·26 | 8 | 1·0673 | 13·46 | 58 |
| 1·0127 | 2·54 | 9 | 1·0679 | 13·58 | 59 |
| 1·0142 | 2·84 | 10 | 1·0685 | 13·70 | 60 |
| 1·0157 | 3·14 | 11 | 1·0691 | 13·82 | 61 |
| 1·0171 | 3·42 | 12 | 1·0697 | 13·94 | 62 |
| 1·0185 | 3·70 | 13 | 1·0702 | 14·04 | 63 |
| 1·0200 | 4·00 | 14 | 1·0707 | 14·14 | 64 |
| 1·0214 | 4·28 | 15 | 1·0712 | 14·24 | 65 |
| 1·0228 | 4·56 | 16 | 1·0717 | 14·34 | 66 |
| 1·0242 | 4·84 | 17 | 1·0721 | 14·42 | 67 |
| 1·0256 | 5·12 | 18 | 1·0725 | 14·50 | 68 |
| 1·0270 | 5·40 | 19 | 1·0729 | 14·58 | 69 |
| 1·0284 | 5·68 | 20 | 1·0733 | 14·66 | 70 |
| 1·0298 | 5·96 | 21 | 1·0737 | 14·74 | 71 |
| 1·0311 | 6·22 | 22 | 1·0740 | 14·80 | 72 |
| 1·0324 | 6·48 | 23 | 1·0742 | 14·84 | 73 |
| 1·0337 | 6·74 | 24 | 1·0744 | 14·88 | 74 |
| 1·0350 | 7·00 | 25 | 1·0746 | 14·92 | 75 |
| 1·0363 | 7·26 | 26 | 1·0747 | 14·94 | 76 |
| 1·0375 | 7·50 | 27 | 1·0748 | 14·96 | 77 |
| 1·0388 | 7·76 | 28 | 1·0748 | 14·96 | 78 |
| 1·0400 | 8·00 | 29 | 1·0748 | 14·96 | 79 |
| 1·0412 | 8·24 | 30 | 1·0748 | 14·96 | 80 |
| 1·0424 | 8·48 | 31 | 1·0747 | 14·94 | 81 |
| 1·0436 | 8·72 | 32 | 1·0746 | 14·92 | 82 |
| 1·0447 | 8·94 | 33 | 1·0744 | 14·88 | 83 |
| 1·0459 | 9·18 | 34 | 1·0742 | 14·84 | 84 |
| 1·0470 | 9·40 | 35 | 1·0739 | 14·78 | 85 |
| 1·0481 | 9·62 | 36 | 1·0736 | 14·72 | 86 |
| 1·0492 | 9·84 | 37 | 1·0731 | 14·62 | 87 |
| 1·0502 | 10·04 | 38 | 1·0726 | 14·52 | 88 |
| 1·0513 | 10·26 | 39 | 1·0720 | 14·40 | 89 |
| 1·0523 | 10·46 | 40 | 1·0713 | 14·26 | 90 |
| 1·0533 | 10·66 | 41 | 1·0705 | 14·10 | 91 |
| 1·0543 | 10·86 | 42 | 1·0696 | 13·92 | 92 |
| 1·0552 | 11·04 | 43 | 1·0686 | 13·72 | 93 |
| 1·0562 | 11·24 | 44 | 1·0674 | 13·48 | 94 |
| 1·0571 | 11·42 | 45 | 1·0660 | 13·20 | 95 |
| 1·0580 | 11·60 | 46 | 1·0644 | 12·88 | 96 |
| 1·0589 | 11·78 | 47 | 1·0625 | 12·50 | 97 |
| 1·0598 | 11·96 | 48 | 1·0604 | 12·08 | 98 |
| 1·0607 | 12·14 | 49 | 1·0580 | 11·60 | 99 |
| 1·0615 | 12·30 | 50 | 1·0553 | 11·06 | 100 |

Acetic acid exerts a solvent action on many metallic oxides and forms with them acetates, most of which are soluble in water; with some, such as the oxides of lead, copper, iron, and a few others, it forms basic acetates, some of which are soluble, but others are insoluble in water. Acetic acid is a monobasic acid. With alcoholic radicles, like ethyl, amyl, etc., it forms acetates which have a pleasant fruity odour and taste.

Glacial acetic acid boils at 118° C., but as acetic acid is volatile in water vapour, solutions of acetic acid volatilise below that temperature in proportion to the amount of acid they contain.

Acetic acid is employed in the colour industry in a variety of operations, as in making white lead, lead acetate, verdigris, etc.

*Assay of Acetic Acid.*—If the acid be pure it is sufficient to titrate a known weight with normal caustic soda, using phenol-phthalein as an indicator, 1 c.c. of normal caustic soda equals 0·06 gramme of acetic acid. If the acid be impure, then a known weight should be distilled and the distillate collected. The distillation must not be carried to dryness, but should be stopped when about three-fourths have come over; a little water is then added to the residue in the retort and the distillation again proceeded with; this process is repeated once or twice. The distillate is now titrated with normal caustic soda, using phenol-phthalein as an indicator and the quantity of acetic acid in the distillate calculated by the factor given above. Acetates may be analysed in the same way, adding a little sulphuric acid to their solution in water before distillation. The presence of free sulphuric acid may be detected by evaporating a little down in an evaporating basin with a small piece of sugar; any blackening that occurs may be taken as an indication of its presence. The addition of any saline matter may be detected by a residue being left on evaporation.

**ACETONE.**—$C_3H_6O$, or $CH_3COCH_3$. When the acetates of lead, calcium or other heavy metals are heated, they give off a light, colourless liquid of a peculiar ethereal odour; this body is acetone and has the composition indicated in the formula given above. Acetone is found in wood spirit to a greater or less extent, dependent upon the wood from which the spirit is distilled.

Acetone is a colourless liquid having a peculiar odour. Its specific gravity is 0·7994 at 13° C. It boils at 56° C. (133° F.): it mixes in all proportions with water, ether and alcohol. It is a powerful solvent of gums, resins, oils and fats. To some extent crude wood naphtha owes its great solvent powers for resins to the acetone it contains. Acetone is sometimes employed in making varnishes as a solvent.

Acetone does not dissolve calcium chloride nor is it soluble in saturated aqueous solutions of that salt; consequently, when acetone or mixtures of acetone with wood spirit or alcohol are shaken up with a saturated solution of calcium chloride, the acetone separates out as a layer on the surface of the liquid.

The quantity of acetone in wood spirit may be ascertained by taking advantage of the fact that by the action of iodine it is converted into iodoform; 1 or 2 c.c. of the sample to be tested is mixed with 10 c.c. of a double normal caustic soda solution, after mixing, there is then added 5 c.c. of a solution of iodine in potassium iodide. This solution may be made from 254 grammes of iodine and 332 grammes of potassium iodide dissolved in 1 litre of water. The iodoform separates out as a yellow precipitate; to the mixture 10 c.c. of ether are added, and, after thorough agitation, the mass is allowed to stand for the ether to separate; the aqueous layer is then drawn off, the ether layer evaporated to expel the ether, and the residual iodoform weighed. 394 parts of iodoform are equal to 58 of acetone.

**ACIDIMETRY** is the name given to the testing of the actual strengths of commercial acids. It is in general done by a volumetric process, which depends on the fact that acids when treated with solutions of sodium hydroxide (caustic soda) are neutralised, and that this reaction takes place in definite proportions. Further, in litmus, methyl orange or phenol-phthalein, we have bodies which are exceedingly sensitive to the action of acids and alkalies. Methyl orange and litmus will turn red with the slightest trace of acid, while phenol-phthalein will show by the production of a red colour the slightest excess of the alkali.

The reactions which occur between caustic soda and various acids are shown in the following chemical equations:—

$$\begin{aligned}
2NaOH + H_2SO_4 &= Na_2SO_4 + 2H_2O \\
NaOH + HCl &= NaCl + H_2O \\
NaOH + HNO_3 &= NaNO_3 + H_2O \\
NaOH + HC_2H_3O_2 &= NaC_2H_3O_2 + H_2O \\
NaOH + HC_{18}H_{33}O_2 &= NaC_{18}H_{33}O_2 + H_2O
\end{aligned}$$

From these equations we can establish the following equivalent proportions: 40 parts of caustic soda (sodium hydroxide) are equal to 49 parts of sulphuric acid, or to 36·5 parts of hydrochloric acid, or to 63 parts of nitric acid, or to 60 parts of acetic acid, or to 282 parts of oleic acid.

In carrying out the principles of acidimetry there is required a solution of caustic soda of known strength; this is called a standard solution, and is usually made to contain 40 grammes of actual NaOH in 1 litre (1,000 cubic centimetres).

As this solution contains the equivalent weight, 40 grammes per litre, of sodium hydroxide, it is called a normal standard solution. Occasionally weaker solutions are required, usually one containing only 4 grammes per litre, and this is called a decinormal solution. A seminormal solution contains 20 grammes per litre.

The usual method of testing is as follows: Weigh out 5 grammes of the acid, transfer to a 250 c.c. graduated measuring flask, fill up the flask to the mark on the neck with water and shake well. Take out 25 c.c. by means of a pipette, and place in a beaker, add about 1 c.c. of phenol-phthalein solution. Fill a burette with the standard solution of caustic soda. When ready turn on the tap of the burette, and allow the solution to drop into the 25 c.c. of the acid solution, stirring it while doing so. The alkaline solution is dropped in until a red colour is obtained, when the number of cubic centimetres used are read off on the burette. The operation is known as titration. It is advisable to repeat it two or three times and to take the mean of the results.

The number of cubic centimetres of caustic soda used are multiplied by the factor according to the particular acid which is being tested, and this gives the quantity of acid in the 25 c.c. taken. The percentage of actual acid in the sample can then be easily calculated.

An actual test of a commercial sulphuric acid worked out as follows: 5 grammes were taken, made up to 250 c.c. with water, 25 c.c. taken for the test.

*Standard Soda*:—

| | |
|---|---|
| Second reading . . . . | 21·3 |
| First reading . . . . . | 12·8 |
| | 8·5 |

8·5 × 0·049 = 0·4165

0·5 : 0·4165 : : 100 = 83·3

The acid contains, therefore, 83·3 per cent. of actual $H_2SO_4$.

The following factors will be useful in the volumetric testing of acids :—

1 c.c. normal sodium hydroxide = 0·049 sulphuric acid.
" " " " = 0·0365 hydrochloric acid.
" " " " = 0·063 nitric acid.
" " " " = 0·060 acetic acid.
" " " " = 0·282 oleic acid.
" " " " = 0·284 stearic acid.

**ALBUMEN.**—A nitrogenous principle or compound of a very complex composition and structure found in the white of eggs, the blood of animals, and in other parts of the animal organism. Other bodies of a similar kind are known as occurring in both the animal and vegetable kingdom, which are known as *albuminoids*. They contain from 50 to 55 per cent. of carbon, 6·0 to 7·5 per cent. of hydrogen, 20 to 24 per cent. of oxygen, 15 to 18 per cent. of nitrogen and 0·3 to 2 per cent. of sulphur. Nearly all contain a small quantity of mineral matter, the bulk of which consists of phosphates. They dissolve in cold or lukewarm water; when heated these solutions undergo coagulation, the albumen changing from a more or less liquid, soluble variety into a solid, insoluble variety. Hence, in drying albumen, or in dissolving solid albumen, it is necessary to avoid high temperatures. The coagulation takes place at temperatures ranging from 50° C. (120° F.) upwards, but varies with the particular kind of albumen. Commercial albumen comes from two sources, the eggs of birds and the blood of animals. These are treated to separate out the albumen, which is then carefully dried at a low temperature to avoid (as far as possible) all chance of coagulation. Albumen comes into the market in the form of flakes, of a pale, yellowish colour, odourless, somewhat hard and brittle. On digesting with water it dissolves, forming a thick, glairy solution. From this solution the albumen may be precipitated by alcohol, acetic acid, potassium ferrocyanide, basic acetic of lead and other metallic salts. Millon's reagent is one of the best of tests for albumen. It is made by treating 10 grammes of mercury with 10 grammes of strong nitric acid. When the first action is over the mixture is gently heated until the mercury is dissolved; twice the volume of water is now added, the mixture allowed to stand for some hours, and the clear supernatant liquid poured off from any sediment which may have formed: this liquid constitutes the test solution. Albuminoids when boiled with this solution produce a red colour.

Albumen solutions are not coagulated on being heated with either dilute hydrochloric acid or dilute caustic soda solutions, being converted into a soluble modification.

Albumen is employed in the colour industry as a vehicle for water colours. For such purposes the albumen solutions ought to be freshly prepared, as they soon undergo decomposition, and give rise to an unpleasant odour. It may be employed as a varnish for paper, imparting to that material a slight gloss: if the paper be dried at a temperature above 130° F., after being coated the coat of albumen will be insoluble and the paper rendered somewhat waterproof.

**ALCOHOL.**—$CH_3CH_2OH$, or $C_2H_5OH$. Spirit of wine. It is a product of the fermentation of saccharine matters, and is produced in large quantities during the fermentation of grape and other fruit juices into wines, from which it may be obtained by distillation, hence its name of "spirit of wine". It is also contained in whisky, rum, brandy and other spirits, and in beers. Alcohol may be taken as the type of a number of bodies possessing similar properties and named "alcohols" by chemists. These bodies possess basic properties, and will combine with acids to form salts, "ethereal salts" as they are called, many of which occur naturally in fruits, and impart to them their peculiar and characteristic odours and tastes.

Alcohols are generally liquid bodies, although a few solid alcohols are known; they are rather volatile and possess characteristic odours. They have great solvent properties. The four most important are: (1) methyl alcohol, $CH_3OH$, found very largely in wood spirit; (2) ethyl alcohol, $C_2H_5OH$; (3) amyl alcohol, $C_5H_{11}OH$, or fusel oil, obtained during the distillation of whisky; and (4) glycerol or glycerine, $C_3H_5OH_3$, the sweet spirit of oils.

**Ethyl Alcohol** (spirit of wine) when pure is a colourless liquid, having a specific gravity of 0·791 at 20° C., 0·7935 at 15° C. It boils at 78·4° C. (173° F.). It possesses a pleasant odour and a sharp, burning taste. It is inflammable, burning with a pale blue lambent flame, with little or no luminosity. It mixes freely with water in all proportions, and for water it has a great affinity, so much so that it is very difficult to prepare alcohol free from water, a circumstance which accounts for the discrepancies which occur between various authorities as regards the specific gravity of pure alcohol. It has a peculiar action on animal membranes. Alcohol is a powerful solvent. With the alkaline metals it forms ethoxides. It dissolves the hydroxides of the alkalies, but not, as a rule, the salts, such as the carbonate, chloride and sulphate. With some salts, chloride of zinc and calcium, it forms molecular compounds or alcoholates as they are called. It dissolves freely many resins: shellac, sandarach, rosin, etc., but there are some resins —animi, copal, kauri—which it will not dissolve. It will dissolve many waxes. Castor oil is completely soluble in alcohol, but on all other fatty oils alcohol exerts but a slight solvent action, and it has little or none on the hydrocarbon oils. It will dissolve nearly all the coal tar colours, hence these are often employed to colour spirit varnishes. It mixes freely with turpentine, ether, chloroform, carbon bisulphide, benzol and some other volatile bodies, but not with petroleum spirit.

It is acted upon by and combines with acids, forming a number of volatile compounds which generally possess an ethereal, pleasant odour.

Alcohol is obtained by preparing a wort from malt, barley, oats, rye and other farinaceous or saccharine bodies, allowing these to ferment, and then separating the spirit by a process of distillation. Alcohol in all its forms is subject to an excise duty of 10s. per proof gallon; what is known as *proof spirit* is alcohol diluted with water to a specific gravity of 0·91984 at 60° F.; such spirit contains 49·24 per cent. of alcohol.

Alcohol has many uses; it is employed as a beverage in various forms, for preparing many medicinal products and preparations, in the preparation of essential oils and fruit essences, in preparing perfumes, in dissolving resins, etc.

It should be mentioned that the production of alcohol is very strictly supervised by the excise authorities.

To determine quantitatively the proportion of alcohol in any alcoholic preparation recourse must be had to the determination of its specific gravity—no very satisfactory chemical test having as yet been devised. The specific gravity test is, however, absolutely reliable when only mixtures of alcohol and water are being dealt with. By distilling alcoholic preparations, such as wines, spirits, etc., the alcohol is given off, and a determination of the gravity of the distillate will give the quantity of alcohol present. This of course assumes that all the volatile matter is alcohol, but this is far from being the case with many spirituous liquors, as some contain aldehyde, acetone or ethereal ethers, all of which are given off and are reckoned as alcohol in the distillate. Still the error cannot be much. The usual plan of procedure is to measure the amount of liquid, to distil until about three-fourths of the liquid has come over, to make up the distillate with distilled water to the original volume (the temperature being at 60° F. exactly), and to take the specific gravity in any convenient way. From the accompanying table the proportion of alcohol in the liquid can be ascertained:—

## TABLE OF SPECIFIC GRAVITY OF ALCOHOL : TEMPERATURE 60° F. (15·5° C.).

| Specific Gravity. | Percentage of Absolute Alcohol by Weight. | Percentage of Proof Spirit by Volume. | Specific Gravity. | Percentage of Absolute Alcohol by Weight. | Percentage of Proof Spirit by Volume. |
|---|---|---|---|---|---|
| 0·79384 | 100 | 175·25 | 0·829 | 87·58 | 160·28 |
| 0·794 | 99·94 | 175·18 | 0·830 | 87·19 | 159·77 |
| 0·795 | 99·61 | 174·83 | 0·831 | 86·81 | 159·26 |
| 0·796 | 99·29 | 174·49 | 0·832 | 86·42 | 158·74 |
| 0·797 | 98·97 | 174·14 | 0·833 | 86·04 | 158·23 |
| 0·798 | 98·66 | 173·81 | 0·834 | 85·65 | 157·71 |
| 0·799 | 98·34 | 173·47 | 0·835 | 85·27 | 157·78 |
| 0·800 | 98·03 | 173·14 | 0·836 | 84·88 | 156·66 |
| 0·801 | 97·70 | 172·77 | 0·837 | 84·48 | 156·10 |
| 0·802 | 97·37 | 172·39 | 0·838 | 84·08 | 155·55 |
| 0·803 | 97·03 | 172·02 | 0·8382 | 84·00 | 155·45 |
| 0·804 | 96·70 | 171·64 | 0·839 | 83·69 | 155·02 |
| 0·805 | 96·37 | 171·26 | 0·840 | 83·31 | 154·40 |
| 0·806 | 96·03 | 170·88 | 0·841 | 82·92 | 153·96 |
| 0·807 | 95·68 | 170·46 | 0·842 | 82·54 | 153·43 |
| 0·808 | 95·32 | 170·03 | 0·843 | 82·15 | 152·89 |
| 0·809 | 94·97 | 169·61 | 0·844 | 81·76 | 152·34 |
| 0·810 | 94·62 | 169·20 | 0·845 | 81·36 | 151·78 |
| 0·811 | 94·28 | 168·79 | 0·846 | 80·96 | 151·21 |
| 0·812 | 93·92 | 168·38 | 0·847 | 80·54 | 150·61 |
| 0·813 | 93·55 | 167·92 | 0·848 | 80·13 | 150·00 |
| 0·814 | 93·18 | 167·46 | 0·849 | 79·72 | 149·38 |
| 0·815 | 92·81 | 167·00 | 0·850 | 79·32 | 148·84 |
| 0·816 | 92·44 | 166·53 | 0·851 | 78·92 | 148·27 |
| 0·817 | 92·07 | 166·07 | 0·852 | 78·52 | 147·69 |
| 0·818 | 91·71 | 165·62 | 0·853 | 78·12 | 147·11 |
| 0·819 | 91·36 | 165·16 | 0·854 | 77·71 | 146·51 |
| 0·820 | 91·00 | 164·74 | 0·855 | 77·29 | 145·89 |
| 0·821 | 90·64 | 164·29 | 0·856 | 76·88 | 145·28 |
| 0·822 | 90·29 | 163·64 | 0·857 | 76·46 | 144·66 |
| 0·823 | 89·92 | 163·38 | 0·858 | 76·04 | 144·04 |
| 0·824 | 89·54 | 162·68 | 0·859 | 75·59 | 143·35 |
| 0·825 | 89·16 | 162·38 | 0·860 | 75·14 | 142·66 |
| 0·826 | 88·76 | 161·86 | 0·861 | 74·68 | 141·96 |
| 0·827 | 88·36 | 161·32 | 0·862 | 74·23 | 141·26 |
| 0·828 | 87·96 | 160·79 | 0·863 | 73·79 | 140·50 |

## TABLE OF SPECIFIC GRAVITY OF ALCOHOL: TEMPERATURE 60° F. (15·5° C.)—*continued.*

| Specific Gravity. | Percentage of Absolute Alcohol by Weight. | Percentage of Proof Spirit by Volume. | Specific Gravity. | Percentage of Absolute Alcohol by Weight. | Percentage of Proof Spirit by Volume. |
|---|---|---|---|---|---|
| 0·864 | 73·38 | 139·96 | 0·893 | 61·08 | 120·42 |
| 0·865 | 72·96 | 139·32 | 0·894 | 60·67 | 119·74 |
| 0·866 | 72·52 | 138·65 | 0·895 | 60·26 | 119·05 |
| 0·867 | 72·09 | 137·98 | 0·896 | 59·83 | 118·34 |
| 0·868 | 71·67 | 137·33 | 0·897 | 59·39 | 117·61 |
| 0·869 | 71·25 | 136·69 | 0·898 | 58·95 | 116·88 |
| 0·870 | 70·84 | 136·07 | 0·899 | 58·50 | 116·11 |
| 0·871 | 70·44 | 135·45 | 0·900 | 58·05 | 115·33 |
| 0·872 | 70·04 | 134·84 | 0·901 | 57·63 | 114·62 |
| 0·873 | 69·63 | 134·19 | 0·902 | 57·21 | 113·92 |
| 0·874 | 69·21 | 133·54 | 0·903 | 56·77 | 113·18 |
| 0·875 | 68·79 | 132·89 | 0·904 | 56·32 | 112·41 |
| 0·876 | 68·33 | 132·23 | 0·905 | 55·86 | 111·64 |
| 0·877 | 67·96 | 131·58 | 0·906 | 55·41 | 110·84 |
| 0·878 | 67·54 | 130·92 | 0·907 | 54·95 | 110·03 |
| 0·879 | 67·13 | 130·26 | 0·908 | 54·48 | 109·20 |
| 0·880 | 66·70 | 129·57 | 0·909 | 54·00 | 108·36 |
| 0·881 | 66·26 | 128·87 | 0·910 | 53·57 | 107·61 |
| 0·882 | 65·83 | 128·19 | 0·911 | 53·13 | 106·86 |
| 0·883 | 65·42 | 127·52 | 0·912 | 52·68 | 106·07 |
| 0·884 | 65·00 | 126·85 | 0·913 | 52·23 | 105·27 |
| 0·885 | 64·57 | 126·15 | 0·914 | 51·79 | 104·50 |
| 0·886 | 64·13 | 125·44 | 0·915 | 51·38 | 103·78 |
| 0·887 | 63·70 | 124·73 | 0·916 | 50·96 | 103·05 |
| 0·888 | 63·26 | 124·02 | 0·917 | 50·52 | 102·28 |
| 0·889 | 62·82 | 123·29 | 0·918 | 50·09 | 101·51 |
| 0·890 | 62·36 | 122·53 | 0·919 | 49·64 | 100·68 |
| 0·891 | 61·92 | 121·79 | 0·91984 | 49·24 | 100 |
| 0·892 | 61·50 | 121·11 | | | |

The above table will usually be found sufficiently extensive by varnish makers and other users of alcohol and methylated spirit; more extended tables will be found in Thorpe's *Dictionary of Applied Chemistry* and in Allen's *Commercial Organic Analysis*, vol. i., to which reference may be made if necessary.

The following gravities are of special interest :—

| | |
|---|---|
| Rectified spirit, "spirit vin. rect." of the pharmacopœia | 0·8382 |
| 56 overproof | 0·8373 |
| 61 " | 0·8272 |
| 64 " | 0·8215 |
| 67 " | 0·8152 |

The table will be found sufficiently accurate for both spirit of wine (alcohol) and methylated spirit.

The detection of methylated spirit when added to any alcoholic preparation is by no means easy, as the properties of ethyl alcohol and methyl alcohol are so similar. The following methods are available :—

(*a*) *Miller's Process :* 3 to 4 c.c. of the spirit to be tested are mixed with 25 c.c. of water, 3 grammes of bichromate of potash and 2½ grammes of sulphuric acid. The mixture is allowed to stand for fifteen minutes, then placed in a flask connected with a condenser and the mixture distilled ; 25 c.c. are collected, a slight excess of sodium carbonate added, the mixture evaporated down until it measures about 10 c.c., and sufficient acetic acid added to give it a feeble acid reaction ; one-tenth of a gramme of silver nitrate dissolved in 3 c.c. of water is then added and the mixture boiled. A mere darkening may be disregarded, but if there be a copious brown or black precipitate and a film of silver appears on the sides of the test glass or tube then the spirit contains methylated spirit.

(*b*) *Reynolds's Test.*—A test for methylated spirit in alcohol depending on the fact that the commercial methyl alcohol contains acetone has been devised by J. E. Reynolds. This is carried out as follows : 200 c.c. of the spirit are taken and 50 c.c. are rapidly distilled off and diluted with an equal volume of water and gently warmed with a little caustic potash. To the mixture a solution of mercuric chloride is cautiously added until the precipitate which first forms is redissolved; too great an excess of mercuric salt should be avoided. The mixture is allowed to stand for a little while to allow some of the alcohol to evaporate off, then the mixture is divided into two portions: to one is added acetic acid, which, if acetone is present, will give a bulky precipitate; the other portion should be boiled for a few minutes, when, if acetone is present, a bulky precipitate will fall down.

(*c*) Another plan is also to take advantage of the presence of acetone in wood spirit and its action on potassium permanganate: 100 c.c. of the spirit to be tested is distilled and the distillate collected in 100 c.c. fractions; to each fraction 1 c.c. of a solution of potassium permanganate is added; if acetone is present the salt will be decomposed in all the fractions, a brown colouration being produced. A brown colouration in the first two fractions only may be disregarded, as this is probably due to the presence of aldehyde in the alcohol. The presence of acetone, and therefore of methyl alcohol, is inferred from all the fractions giving a brown colouration.

The following impurities are sometimes present in commercial alcohol and methylated spirit:—amyl alcohol or fusel oil, which may be detected by placing some of the spirit in a basin and allowing it to evaporate; if fusel oil is present the final portions will have the characteristic odour; mineral and organic impurities of a fixed character may be detected by evaporating some of the spirit in an evaporating basin on the water bath when they will be left behind; their nature may be ascertained by a subsequent test. On adding water to spirit which contains oily and resinous matters in solution a white turbidity is obtained. Acetic acid, if present, may be detected by the spirit having an acid reaction and on allowing some to evaporate the odour of acetic acid becomes perceptible.

Aldehyde is sometimes present in spirit. It causes the latter to become brown when boiled with caustic soda and to give a black precipitate with silver nitrate. See also *Methyl Alcohol*, *Methylated Spirit*, *Wood Naphtha*.

**ALIZARINE LAKES.**—A series of lake pigments made from the coal tar dyestuff alizarine by combining it with freshly precipitated alumina or chromium hydroxide. These lakes possess some brilliancy of colour, good colouring power, but not much covering power or body. They are quite permanent, in this respect excelling all other lakes. Pure alizarine lakes are distinguished by the following tests: Strong acids dissolve the metallic base and liberate the free alizarine as a brownish-red powder. Alkalies will dissolve the lake more or less completely, according to the particular base with which the lake has been made, the solution having a bluish-red colour; on adding strong acids to this the colour is discharged and alizarine is precipitated.

**ALKALIMETRY.**—See under *Caustic Soda*.

**ALUM.**—This important salt is the double sulphate of aluminum and potash, and it has a composition corresponding to the formula $K_2Al_24SO_424H_2O$, and it contains 9·91 per cent. potash ($K_2O$), 10·84 per cent. alumina ($Al_2O_3$), 33·73 per cent. sulphur trioxide ($SO_3$), and 45·52 per cent. water. It crystallises in the shape of clear transparent crystals of an octahedral form; these contain 45·5 per cent. of water of crystallisation. Alum is soluble in about 18 times its weight of cold water, and in less than its own weight of boiling water. Its taste is sweetish and astringent. The solution in water has a strongly acid reaction. When heated it gradually loses its water of crystallisation, and at about

392° F. it becomes anhydrous and nearly insoluble in water.

Alum is made by digesting aluminous earths with sulphuric acid, treating the mass with water, and adding to the solution potassium sulphate, after which the alum is allowed to crystallise out.

Alum is used in the paint trade for the manufacture of lakes, and for this purpose it ought to be pure and in particular free from iron. This impurity used to be very common at one time, but now alum is made very free from it. When a solution of potassium ferrocyanide is added to a solution of alum no blue precipitate or colouration indicating the presence of iron should be produced. The value of alum depends upon the quantity of alumina it contains, and this may be determined by weighing out 2 grammes, dissolving in water, and then adding ammonia ; this throws down a white gelatinous precipitate of aluminum hydroxide. This precipitate is collected on a filter, washed, dried, burnt in a crucible and weighed in the usual manner. The weight obtained gives the weight of alumina in the sample taken. By multiplying by 50 the percentage is got.

**Alums.**—The characteristic features of alum as noted above are that it crystallises in octahedral crystals containing 24 molecules of water of crystallisation, and is a double sulphate of aluminium and potassium. If in the course of preparation sodium sulphate or ammonium sulphate be used, then salts are obtained which crystallise in precisely the same way as alum, and these are also called alums, and to distinguish the three salts the prefixes potash or soda or ammonia alum are used. It is found further that the aluminium may be replaced by iron or chromium or manganese to form double sulphates which all crystallise in the same way and have similar formula: thus we may have:—

| | |
|---|---|
| Potassium alum | $K_2Al_2 4SO_4 24H_2O$ |
| Sodium alum | $Na_2Al_2 4SO_4 24H_2O$ |
| Ammonium alum | $(NH_4)_2Al_2 4SO_4 24H_2O$ |
| Iron alum | $K_2Fe_2 4SO_4 24H_2O$ |
| Chrome alum | $K_2Cr_2 4SO_4 24H_2O$ |
| Manganese alum | $K_2Mn_2 4SO_4 24H_2O$ |

See translation of Geschwind's *Sulphates of Aluminium and Iron and Alum.*

Commercially the term alum is restricted to the potassium or ammonium aluminium compounds, and the maker makes one or the other as it suits him. So far as practical work is concerned the potassium, sodium and ammonium alums give identical results; the former contains the least, 10·84 per cent., the latter the most, 11·35 per cent., alumina, but the difference is slight.

Chrome alum is the only one of the other alums that the colour maker is at all interested in.

**Aluminium Sulphate.**—This preparation is now largely in use in colour making. It is a white amorphous mass usually having the composition 15·44 per cent. alumina ($Al_2O_3$), 35·98 per cent. sulphur trioxide ($SO_3$), and 48·58 per cent. of water. The formula is $Al_2 3SO_4 18H_2O$. It is more freely soluble in water than alum, one part in two parts of cold water, and on that account is rather preferable to alum. It should be free from iron (which can be tested for as described above). The amount of alumina it contains is estimated as in the case of alum.

**ALUMINA HYDRATE** has the formula $Al_2H_6O_6$. It is sold as a white powder, which usually contains 98 to 99 per cent. of alumina hydroxide, better known as alumina hydrate. It is fairly easily soluble in acids without leaving any residue, the solutions being colourless; from them the hydroxide is reprecipitated on addition of ammonia or the carbonates of the alkalies. In the freshly precipitated condition it is employed in the preparation of lakes; it is also employed in the manufacture of porcelain to increase the transparency of the body, and also along with cobalt to produce blue colours.

**AMMONIA.**—The valuable commercial article, liquor ammonia, is really a solution of the gas ammonia in water.

SPECIFIC GRAVITIES OF LIQUOR AMMONIA.

| Specific Gravity. | Per Cent. $NH_3$. | Specific Gravity. | Per Cent. $NH_3$. | Specific Gravity. | Per Cent. $NH_3$. |
|---|---|---|---|---|---|
| 0·8844 | 36·0 | 0·8976 | 30·0 | 0·9133 | 24·0 |
| 0·8848 | 35·8 | 0·8981 | 29·8 | 0·9139 | 23·8 |
| 0·8852 | 35·6 | 0·8986 | 29·6 | 0·9145 | 23·6 |
| 0·8856 | 35·4 | 0·8991 | 29·4 | 0·9150 | 23·4 |
| 0·8860 | 35·2 | 0·8996 | 29·2 | 0·9156 | 23·2 |
| 0·8864 | 35·0 | 0·9001 | 29·0 | 0·9162 | 23·0 |
| 0·8868 | 34·8 | 0·9006 | 28·8 | 0·9168 | 22·8 |
| 0·8872 | 34·6 | 0·9011 | 28·6 | 0·9174 | 22·6 |
| 0·8877 | 34·4 | 0·9016 | 28·4 | 0·9180 | 22·4 |
| 0·8881 | 34·2 | 0·9021 | 28·2 | 0·9185 | 22·2 |
| 0·8885 | 34·0 | 0·9026 | 28·0 | 0·9191 | 22·0 |
| 0·8889 | 33·8 | 0·9031 | 27·8 | 0·9197 | 21·8 |
| 0·8894 | 33·6 | 0·9036 | 27·6 | 0·9203 | 21·6 |
| 0·8893 | 33·4 | 0·9041 | 27·4 | 0·9209 | 21·4 |
| 0·8903 | 33·2 | 0·9047 | 27·2 | 0·9215 | 21·2 |
| 0·8907 | 33·0 | 0·9052 | 27·0 | 0·9221 | 21·0 |
| 0·8911 | 32·8 | 0·9057 | 26·8 | 0·9227 | 20·8 |
| 0·8916 | 32·6 | 0·9063 | 26·6 | 0·9223 | 20·6 |
| 0·8920 | 32·4 | 0·9068 | 26·4 | 0·9239 | 20·4 |
| 0·8925 | 32·2 | 0·9073 | 26·2 | 0·9245 | 20·2 |
| 0·8929 | 32·0 | 0·9078 | 26·0 | 0·9251 | 20·0 |
| 0·8934 | 31·8 | 0·9083 | 25·8 | 0·9257 | 19·8 |
| 0·8938 | 31·6 | 0·9089 | 25·6 | 0·9264 | 19·6 |
| 0·8943 | 31·4 | 0·9094 | 25·4 | 0·9271 | 19·4 |
| 0·8948 | 31·2 | 0·9100 | 25·2 | 0·9277 | 19·2 |
| 0·8953 | 31·0 | 0·9106 | 25·0 | 0·9283 | 19·0 |
| 0·8957 | 30·8 | 0·9111 | 24·8 | 0·9289 | 18·8 |
| 0·8962 | 30·6 | 0·9118 | 24·6 | 0·9296 | 18·6 |
| 0·8967 | 30·4 | 0·9122 | 24·4 | 0·9302 | 18·4 |
| 0·8971 | 30·2 | 0·9127 | 24·2 | 0·9308 | 18·2 |

Ammonia gas is a compound of nitrogen and hydrogen in the proportions by volume of 1 of the former to 3 of the latter, or by weight 14 parts of nitrogen to 3 parts of hydrogen.

Its chemical formula is $NH_3$. It is characterised by possessing a strong and peculiar odour, with an irritating effect on the nostrils and eyes, and by this means it is readily detected. Ammonia gas is readily soluble in water, 1 volume of the latter taking up 1,050 volumes of the gas at the freezing point; but the solubility rapidly decreases, and at 77° F. only 536 volumes are taken up. A saturated solution at 60° F. contains 0·582 of its weight of the gas. The liquor ammonia of commerce is prepared by heating various ammonium compounds with quicklime and passing the evolved ammonia gas into water. The absorption of the gas increases the volume of the liquid so that the gravity of liquor ammonia is less than that of water. The table after Carius, on the preceding page, gives the gravities and strengths of various solutions of ammonia.

The usual strength sold is known as 884 or 29° B., and contains 36 per cent. of actual ammonia. A weaker ammonia of 0·913 or 24° B. is also made containing about 24 per cent. of ammonia.

Ammonia is a volatile liquid, and evaporates completely away when exposed to the air or boiled. It is a powerful base uniting with and neutralising all acids, and in doing so it forms a series of salts generally called the ammonium or ammoniacal salts, many of which, such as the chloride, sulphate, nitrate and carbonate are of considerable service.

Liquor ammonia if pure should leave no solid residue when evaporated; the presence of carbonic acid may be detected by the addition of lime water, a white turbidity showing its presence. Chlorine can be detected by neutralising with nitric acid, and adding silver nitrate, a white precipitate of silver chloride shows its presence. Sulphuric acid is detected by adding barium chloride, when a white precipitate of barium sulphate is formed if it be present. The presence of lime is shown by the formation of a white turbidity on adding ammonium oxalate. Care should always be taken when mixing ammonia with acids; the action is very energetic, and much heat is evolved.

If the liquor ammonia is pure then the determination of its specific gravity is sufficient to ascertain its strength. A volumetric test can be made as described under caustic soda (alkalimetry), the factor for the calculation being 0·017.

Ammonia will dissolve many gums and resins.

**AMYL ACETATE.**—This substance is being applied to the preparation of certain kinds of varnishes as a solvent for gum dammar, gum sandarach, gun cotton, pyroxylin, etc. It is a colourless liquid, limpid, with a fragrant odour of pears. Its specific gravity is 0·8774 at 60° F. It boils at 137° C. (280° F.). It is slowly volatile on exposure to the air. Is combustible, but does not burn very freely. Its chemical formula is $C_5H_{11}C_2H_3O_2$. It is prepared by distilling mixtures of amyl alcohol, sodium acetate and sulphuric acid. The purity of the sample depends upon the purity of the amyl alcohol used, but for use in varnish-making these impurities are of little moment.

**AMYL ALCOHOL,** $C_5H_{11}OH$, is a member of the paraffin series of alcohols. In a crude form it comes largely into commerce as fusel or fousel oil, which is obtained in the distillation of whisky from potatoes and barley. Several isomeric amyl alcohols are known which differ in their physical and chemical properties. Normal amyl alcohol, for instance, boils at 137° C., and has a specific gravity of 0·820. Iso-amyl alcohol boils at 130° C., and has a specific gravity of 0·8148. This variety is produced during the fermentation of starch or cereals, and is, therefore, the principal constituent of fusel oil. It is this variety which is of most commercial importance.

Fousel or fusel oil is formed, as above stated, during the fermentation of potatoes, barley, etc., for the production of spirits. In the separation of the spirituous liquors it is chiefly found in the last portions of the distillate, which are kept separate, as the fusel oil, getting into the spirit, would spoil its taste.

Fusel oil is a mixture of ethyl alcohol, normal and isopropyl alcohols, normal and iso-butyl alcohols, and normal and iso-amyl alcohols, together with traces of aldehyde and ethers. Its composition will vary from time to time, according to the care taken in isolating it from the first distillates of the spirit.

Fusel oil may be employed in the preparation of varnishes as a solvent.

Amyl alcohol is obtained from the last runnings of spirits by agitating them with strong brine, separating the oily layer, treating this with milk of lime, and then distilling and collecting apart that portion which passes over between 125° C. and 140° C. A purer product can be obtained by further treatment with milk of lime and distilling between 128° C. and 132° C. Amyl alcohol is a colourless liquid, having a peculiar odour and strong acrid taste. It has a specific gravity of 0·8148, and boils at 128° C. to 132° C. It is soluble in 39 times its volume of water, and this solution has a specific gravity of 0·998, while amyl alcohol dissolves about one-eleventh of its volume of water, and that solution has a specific gravity of 0·835. Amyl alcohol mixes in all proportions with alcohol, ether, chloroform, carbon bisulphide, petroleum ether, with which it mixes more freely than does ethyl alcohol; it is a good solvent for all essential oils, many resins, iodine, camphor, etc.

Mixed with strong sulphuric acid in the cold it gradually combines with it and forms amyl sulphuric acid, a red colour being obtained. This product mixes with water and alcohol; it is decomposed on heating. Heated with strong acetic acid, or an acetate and sulphuric acid, amyl acetate is obtained, which possesses the odour of jargonelles. Heated with potassium bichromate and sulphuric acid, amyl alcohol gives rise to valeric aldehyde and valeric acid, which possess a characteristic odour. Amyl alcohol may be separated from contaminating ethyl alcohol by shaking it up with water, in which it does not dissolve, while the ethyl alcohol is freely miscible therewith; the separation is, however, not quite complete. An approximate test of the amount of ethyl alcohol in a sample of mixed amyl and ethyl alcohols may be made as follows: The sample is taken and shaken in a graduated tube with a measured volume of petroleum spirit; on adding water the petroleum spirit separates; the increase in its volume is a measure of the amount of amyl alcohol present.

**AMBER.**—Amber is a resinous matter which is found fossil in a narrow belt in the greensand beds of the cretaceous formation extending from Norfolk in England through Holland, the Baltic coasts of Germany, Russia, Siberia, to America. The quantity found in this country is of a very unimportant character; the great bulk, if not the whole, of the amber of commerce comes from the Baltic provinces of East Prussia. The tree or trees which yielded amber are not known; some authorities consider that the bulk of it was produced by a tree of the coniferous type. Most of the European supply of amber is washed up by the waves of the Baltic Sea from deposits which are now submerged. In West Prussia there are deposits which are mined by a regular system of mining; shafts are sunk, the material containing the amber is brought to the surface, and is there washed with water, and passed through sieves, which retain the amber, but allow the fine earth to pass through. Although it may be picked up, especially after a storm, on the coasts of Norfolk, Suffolk and Essex, the quantity is too small and the supply too precarious to make it worth while to collect it.

Amber comes into commerce in pieces of varying size and colour. That which is mined is usually of an angular shape, but that washed up from the sea has a rounded shape. In colour it varies very considerably, from a dull white, through pale yellow to brown and red, while even blue and green amber is not unknown. The commercial value of amber depends upon the size and colour; the largest and palest pieces are the most valuable, and are chiefly used for ornaments, pipe mouthpieces, etc. The small and dark-coloured pieces are used for making varnishes, amber oil, etc., where size and colour are not of much importance.

In the trade the following are the chief varieties of amber which are recognised: (1) "Shining," pale yellow or greenish in colour, and very bright in appearance; (2) "Bastard," opaque in appearance, and rather darker in colour; (3) "Bone colour," a dull white in colour, due to the presence of included water, this variety is usually very rich in succinic acid, and is mostly employed for preparing that substance; (4) "Agate colour," employed for ornaments; (5) "Impure," this variety contains remains of flies and other insects and of vegetable matter; (6) "Cloudy," this variety varies somewhat in colour, which is unevenly distributed through the pieces; (7) "Transparent," this is clear, but varies considerably in colour, it is used for a variety of purposes, mouthpieces of pipes, etc.

Amber has a specific gravity of 1·074 to 1·094; it is insoluble in water, ammonia, carbon bisulphide, petroleum spirit, benzol, and acetic acid, but slightly soluble in absolute alcohol, turpentine, ether, chloroform and some essential oils. Boiled in either linseed or rape oil for some hours it becomes softened and can then be moulded ; on exposure to the air its original hardness is gradually restored. Its melting point is high, from 310° to 320° C. (600° to 615° F.). When subjected to dry distillation it gives off a quantity of succinic acid and a liquid oil, which is known in commerce as amber oil : a solid residue is left behind. This solid residue, which has a resinous appearance, is soluble in hot linseed oil, chloroform, ether, benzol, petroleum spirit and turpentine, but is insoluble in alcohol. This property of fused amber, being soluble, is taken advantage of in the manufacture of amber varnish, for the details of which the reader is referred to the author's *Manual of Painters' Colours, Oils and Varnishes.*

Amber oil is a pale amber-coloured oil having a specific gravity of 0·9606 at 60° F. It has a peculiar odour, and has a turpentinous composition. Amber yields about 20 to 23 per cent. of its weight of this oil, which is employed in perfumery and medicine.

Artificial amber has been made by melting copal resin and dissolving it in a small quantity of turpentine containing camphor ; on evaporation of the solvent an amber-like resin is left.

Amber is distinguished by its electrical properties, which are rendered evident on rubbing it, its high melting point, and its solubility in most solvents : when heated it evolves succinic acid, the vapour of which substance has a peculiar irritating effect on the throat and excites coughing.

**AMERICAN YELLOW.**—A chrome yellow made with alum and barytes in addition to acetate of lead and bichromate of potash. See *Chrome Yellow.*

**AMERICAN VERMILION.**—This is the basic chromate of lead, having the formula, $PbO, PbCrO_4$. It is better known as *Derby Red*, which see.

**ANILINE BLACK** is a product of the oxidation of aniline or toluidine, two amido bodies found in coal tar, and prepared on a large scale from coal-tar products. It has been prepared and offered for use as a pigment, but for this purpose its use is by no means satisfactory. It has a strong action on the oil, does not possess much body, and further, it has a strong oxidising action on oils. See also Jennison's *Manufacture of Lake Pigments from Artificial Colours;* Bersch's *Manufacture of Mineral and Lake Pigments.*

**ANILINE LAKES.**—A large number of pigments are now prepared from the coal-tar dyes, such as Magenta, Scarlet R., Indian Yellow, Patent Blue, etc., and are sold under a variety of special names, the *Vermilionettes* and *Royal Reds* (which see) being perhaps the most familiar. Aniline lakes consist of three main portions: (1) the base, or, as some prefer to speak of it, the diluent, consisting of a body, such as barytes, white lead, orange lead, gypsum, zinc white, to which in most cases the covering power and the body of the pigment is due; (2) the colouring matter forming from 3 to 10 per cent. of the actual lake, and on the specific properties of which the colour and permanency of the lake pigment depends; and (3) the precipitant, whose function is to enter into chemical combination with the dye and form with it an insoluble product, the colour lake, the combination of which in a mechanical manner with the base forms the lake pigment. The use of these lake pigments is growing, and is likely to grow, as by their means pigments can be made that cannot be produced by other means. The method of making them is fully discussed in the author's *Manual of Painters' Colours.*

**ANIMAL BLACK.**—Under this name are sold black pigments employed in making paints and for decolourising liquors, oils, etc. These are made by charring, in closed retorts or vessels, animal matter of various kinds, horns, skin parings, leather cuttings, hoofs, etc. In making potassium ferrocyanide (yellow prussiate of potash) a large quantity of black, "prussiate char," is made which may also be regarded as an animal black. These blacks owe their colour to carbon, which they contain in very variable amounts; they often contain water and some mineral matter, which usually consists of carbonate of lime and phosphate of lime. The following analysis have been made by the author of samples of animal black:—

| | Per Cent. 1. | Per Cent. 2. | Per Cent. 3. |
|---|---|---|---|
| Water . . . | 28·75 | 28·11 | 36·70 |
| Ash . . . | 29·22 | 30·71 | 34·80 |
| Carbon . . . | 42·03 | 41·18 | 28·50 |

The proportion of water in these samples is rather excessive, and will prevent the blacks from being serviceable as oil paints, but for making blacking or for decolourising purposes they are quite suitable. Bone blacks are also animal blacks; they are described under *Bone Black.*

**ANIMI.**—Gum animi is the name of a resin which is found in fairly large quantities in the island of Zanzibar and on the adjoining African mainland. It is principally exported from Zanzibar, although some finds its way to England through Aden, Suez, Bombay and other ports.

Animi is found in two forms, "fossil" and "recent" or "virgin"; of these two sorts the fossil is by far the best and is employed in making all the best coach varnishes; while the recent variety is mostly used locally and in India to make inferior varnishes. Both varieties are probably the product of trees; the tree which yielded the fossil animi is now unknown, but possibly it may be the same as that from which the recent animi is obtained.

Fossil animi is obtained by digging in the sands of the coast during the rainy season when the ground is soft; it is taken by the diggers to Zanzibar and sold to the merchants, who clean it ready for the European markets. The surface of the resin is covered with a red crust formed by a decomposition of the resin and an amalgamation with the soil which has a red colour; on removing this crust one peculiarity of animi becomes apparent, the existence of what is called the "goose skin"; that is, the surface of the resin is covered with a number of small indentations closely resembling the skin of a plucked goose, whence its name.

Animi occurs in homogeneous pieces of various sizes; it is clear and transparent, and of a yellowish to a brownish-yellow colour. It often contains the remains of insects, much after the manner of the proverbial "fly in amber". It is hard and cannot be scratched by the finger nail; it breaks with a conchoidal fracture, and the surfaces have a glossy lustre. The specific gravity of animi is 1·062 to 1·068.

It is nearly insoluble in all the ordinary solvents. Ether has little action, a small portion only passing into solution; petroleum ether causes it to swell up into a white mass, but has little solvent action; chloroform partially dissolves it; alcohol causes it to swell. In any case long digestion is required to bring about any action between the solvent and the resin. Boiling caustic soda or moderately strong acids do not appear to have any action on animi.

When animi is distilled it gives off a quantity of brownish vapours, which, however, disappear when the resin has become quite fluid. The resin loses some 20 per cent. in weight, of which about 2 per cent. is water, while the rest consists of a brownish-coloured oil having a specific gravity of 0·908, and a strong empyreumatic odour. This oil mixes readily with benzene, ether, petroleum spirit and turpentine, but is insoluble in alcohol, and has properties which would indicate it to have a turpentinous composition.

The residual resin in the retort, on cooling, sets into hard, clear, transparent resin, soluble in benzene, chloroform, petroleum spirit, turpentine, and in hot linseed oil. In ether it gives a cloudy solution, while it is insoluble in alcohol.

Animi has a melting point of 240° C. to 250° C. (450° F. to 465° F.).

Animi is employed in the manufacture of the best grades of coach varnishes.

"Recent" or "virgin" animi is collected direct from the trees or picked up off the ground on to which it has fallen by the natives, who make a business of collecting animi. It is said to be yielded by the tree *Trachylobium mosambiconse*, but this is open to doubt. The native Arabs call the tree "shajar el sandarus," and the resin itself "shakazi"; but different tribes have different names for it.

Recent animi has a pale colour, a smooth surface and a dull appearance; it is soft and closely resembles gum-arabic in consistency. Very little comes into this country, most of it going to India, where it is employed in making inferior varnishes.

Resins from other countries have been imported under the name of animi, but they are very inferior to the true animi, which is only imported from Zanzibar in quality or value as varnish resins. Some of these will be found described further on. See *Demerara Animi*.

**ANNATTO,** variously spelled Arnotto, Arnatto, is a colouring matter extracted from the fruit capsules of the *Bixa* *orellana*, an evergreen plant growing in the East and West Indies and in South America. The colouring matter is present in the pulpy mass which surrounds the seeds, and is extracted by bruising with water and allowing the mass to ferment. The aqueous extract is evaporated until a thick paste is obtained. The colouring matter is not very freely soluble in water, but readily dissolves on adding a little alkali; the solution has bright orange colour; the odour of the aqueous decoction is peculiar, while its taste is very bitter. On adding acid to either an aqueous or an alkaline decoction, the colouring matter is thrown down as an orange-coloured precipitate.

The colouring principle of annatto is known as *bixin*, of which but little is known; to it is assigned the formula, $C_{16}H_{26}O_2$; on treatment with alkalies and exposure to the air, it absorbs oxygen and passes into a body named *bixein*. Annatto is very variable in composition. Wynter Blyth gives an analysis of a good sample as containing colouring matter, 28·8 per cent.; ash, 22·5 per cent.; extractive matter, 24·5 per cent.; and water, 24·2 per cent.

Annatto is employed in dyeing, as also for colouring butter and varnishes.

**ANTIMONY** is a very useful metal, found naturally in the mineral, stibnite or black antimony, which is the sulphide of the metal, having the formula $Sb_2S_3$; other minerals containing antimony are known. Antimony, to which is assigned the symbol Sb, has an atomic weight of 120. It is a bright, highly crystalline substance, very brittle, and is easily ground into a fine powder. It has a specific gravity of 6·7 to 6·8. It is perfectly stable when exposed to the air, not being prone to oxidation. It is not acted upon by dilute acids; strong hydrochloric and sulphuric acids dissolve it with the formation of the chloride and sulphate of antimony.

Nitric acid oxidises it to either the trioxide or the pentoxide, according to the strength of the acid. Antimony is employed in the preparation of certain alloys, type metal (lead, antimony and tin), Britannia metal (copper, tin and antimony). It enters into the composition of a few pigments, antimony vermilion, Naples yellow, etc.

**ANTIMONY ORANGE** is a pigment prepared by passing sulphuretted hydrogen gas through a solution of the chloride of antimony; it consists, therefore, of the sulphide of antimony $Sb_2S_3$. It is a bright orange in colour, voluminous and flocculent in character; it has good body or covering power, in consequence of its opacity, and mixes well with either water or oil; it cannot be used with alkaline vehicles, like silicate of soda or lime, as these have a decolourising tendency; it is unaltered by exposure to light and air.

Dilute acids have no action on antimony orange. Strong nitric acid decomposes it with the formation of an insoluble white oxide of antimony and sulphuric acid. Boiling hydrochloric acid dissolves it with the formation of the chloride of antimony. Caustic alkalis dissolve the pigment, forming colourless solutions.

The following analysis shows the average composition of antimony orange:—

2·20 per cent. of water.
40·55 „ „ sulphur.
56·99 „ „ antimony.

In this case the sulphur is in excess of that required to combine with the antimony as sulphide. This excess is probably present as free sulphur, and its presence is due to employing too strong a solution of the chloride in preparing the pigment, and is the consequent decomposition of some of the sulphuretted hydrogen. Antimony oranges which contain an excess of sulphur in their composition, are not so permanent in character as those in which the two elements are present in the normal proportions, which are 71·42 per cent. of antimony and 28·28 per cent. of sulphur.

**ANTIMONY VERMILION** is a scarlet-red pigment prepared from antimony chloride by precipitation with sodium thiosulphate. It has a bright vermilion-like colour, and is somewhat more dense in character than antimony orange. In composition and proportion it is identical with the orange variety. A sample analysed by the author contained:—

4·22 per cent. of water,
27·10 ,, ,, sulphur,
68·67 ,, ,, antimony,

which shows that this pigment was nearly pure antimony sulphide. Both antimony orange and antimony vermilion are employed for colouring rubber; being sulphides they do not interfere with the vulcanising of the rubber, while the sulphur used in that operation has no effect on them.

**ANTIMONY YELLOW** is a name often given to *Naples Yellow*, which see.

**ANTWERP BLUE.**—This blue is a light shade blue, formerly in much request, but now replaced by the Brunswick blues. It is probably a mixture of the ferrocyanides of iron (to which its colour is due), zinc and alumina. Boiled with alkalies its blue colour is discharged and a brownish residue is left behind; after washing with water this is completely soluble in hydrochloric acid, and gives the tests for iron, alumina and zinc. The alkaline solution contains ferrocyanide of sodium, and after acidifying, will give a blue precipitate, with solutions of iron salts.

**ARABIC,** a gum much used for its strong adhesive properties. See *Gum-Arabic.*

**ARSENIC,** one of the elementary bodies, has the atomic weight of 75 : to it has been assigned the symbol As. Arsenic, so far as its chemical properties are concerned, lies on the border line between the true non-metals, like chlorine and the true metals, like copper : it can play the parts of either, according as circumstances permit it. Thus it acts like a metal in combining with chlorine or bromine, but with strong bases like sodium, or even copper, it will enter into combination and play the part of an acid. Arsenic is a steel-grey metallic substance having a strong lustre ; it has a specific gravity of 5·62 to 5·96, and is a good conductor of heat and electricity. It is very brittle and may be easily powdered. By heat it is converted into a yellow vapour, which has a peculiar garlic-like odour. When treated with nitric acid and other oxidising agents, arsenic is converted into arsenic oxide, $As_2O_5$, which combines with sodium or other alkali metals to form arsenates. When heated arsenic will burn, and is then converted into arsenious oxide, $As_2O_3$, which is known commercially as white arsenic. This body is soluble in alkaline liquors, forming the arsenites of the alkali metals. The arsenites of the heavy metals, copper, lead, etc., are insoluble in water. Scheele's green is an arsenite of copper, while emerald green is an aceto-arsenite of copper.

With sulphur arsenic combines to form two sulphides, the arsenic disulphide, $As_2S_2$, and the arsenic trisulphide, $As_2S_3$, both of which occur naturally, the former as realgar, the latter as orpiment. Both are yellow in colour and have been used as pigments; the trisulphide is also obtained as a bright yellow precipitate when a current of sulphuretted hydrogen gas is passed through a solution of arsenious oxide; it then forms the pigment known as king's yellow. A pentasulphide is also known.

Arsenic in all its forms is exceedingly poisonous, although its degree of activity depends very much upon the peculiar idiosyncrasy of the individuals subjected to its action. There are some persons who could not go into a room coloured with emerald green without being affected, while on others it has no effect. It is advisable, however, to avoid the use of arsenic in pigments and colours as much as possible; arsenic products are gradually going out of use. The best test for arsenic is Marsh's test. It depends on the fact that arsenic is capable of forming with hydrogen a volatile gas known as arseniuretted hydrogen, this gas being always formed when arsenic compounds are brought into contact with materials capable of evolving hydrogen. A small bottle is provided with a tightly fitting cork, through which is bored a hole, in which is fitted a glass tube drawn out to a jet. In the bottle is placed a little water, a few pieces of zinc and some sulphuric acid, particular care being taken that the materials used be free from arsenic. Commercial zinc and commercial sulphuric acid are very liable to contain that metal as an impurity. Hydrogen will be evolved; if, after the lapse of a few minutes, to allow the air in the bottle to be expelled, a light be applied to the end of the glass tube, the gas will burn with a pale blue flame; if, now a cold porcelain basin be pressed down for a moment on the flame, the basin will not be discoloured in any way. Next put in the bottle the material to be tested and relight the gas at the end of the glass tube. If arsenic be present the gas will burn with a whitish flame, and on pressing the basin on the flame a grey spot will be formed. This deposit is one of metallic arsenic. This is a most delicate test for arsenic, and will show small traces of it. There is only one other metal which will give a similar reaction, and that is antimony. When relatively large quantities of it are present then a stain will be formed of antimony on the basin under the same conditions. The two stains may be distinguished by the fact that the arsenic stain is soluble, but the antimony stain insoluble, in a solution of bleaching powder.

**ARSENIC ORANGE.**—This is a disulphide of arsenic, $As_3S_2$. It is found naturally as the mineral realgar, and is made artificially by subliming a mixture of arsenic and sulphur. It has but a slight orange colour, no great colouring or covering properties, and is now but rarely used as a pigment. In its chemical properties it resembles *Arsenic Yellow*.

**ARSENIC YELLOW** or **KING'S YELLOW** is the trisulphide of arsenic, $As_2S_3$. At one time it was extensively used as a pigment, but the discovery of the chrome yellows has almost, if not quite, completely displaced it. It is found naturally as the mineral orpiment, and is made artificially by passing a current of sulphuretted hydrogen gas through a solution of arsenious oxide. It is soluble in hydrochloric acid to a colourless solution. Caustic soda dissolves it with the formation of a thioarsenate of soda; on adding acids to this solution the yellow is reprecipitated. As a pigment it possesses a fair body, but is not durable on exposure to light.

**ARSENIOUS OXIDE.**—This body is known commercially as arsenic or white arsenic. It is obtained by the burning in suitable furnaces of arsenic vapour and the collection of the fumes of oxide so produced in long flues. The commercial article is fairly pure, containing but small quantities of impurities. It is insoluble in water, easily soluble in solutions of the caustic or carbonate alkalies, forming arsenites. It is also soluble in hydrochloric acid. On heating it is volatilised, the vapour having the odour of garlic, and easily condensing to the solid form. Arsenic is employed in the manufacture of Scheele's emerald and mineral greens. See *Scheele's Green, Mineral Green.*

**ASPHALTUM.**—This substance is chiefly employed in the preparation of varnishes, such as black japan, Brunswick black, Berlin black, etc. It was originally obtained from the shores of the Dead Sea, and hence is sometimes known as bitumen of Judea. It is imported from Syria, Egypt, Albania, South America, Barbadoes, Trinidad and other places. It is a blackish-brown solid, breaking with a conchoidal fracture, the surfaces being lustrous. It melts at 100° C. to a black liquid having a strong, pitchy odour. It is combustible, burning with a bright but somewhat smoky flame. It is insoluble in water and in alcohol, not very soluble in turpentine, but easily soluble in coal-tar naphtha. The specific gravity of asphaltum ranges from 1·00 to 1·02. The exact chemical composition of asphaltum has not yet been ascertained. The general assumption is that it is allied to petroleum and the paraffins. Probably the asphaltum from different places would be found to exhibit some differences in the same way as petroleums differ from one another.

Artificial asphaltums have been made by melting or mixing together rosin, coal-tar, wool and other pitches. These are employed in preparing cheaper black varnishes than can be obtained from the natural asphaltum.

**AUREOLIN** is a pigment prepared almost solely for artists' use. It is the double nitrite of cobalt and potassium, and possesses a fine yellow colour; it fades on exposure to light and air.

**AZURE BLUE** is a name sometimes given to *Cobalt Blue.*

**AZURITE.**—This body is a mineral of a fine blue colour, found pretty widely distributed; sometimes in hard pieces, at other times in loose friable masses. It is a basic carbonate of copper, containing 25·6 per cent. of carbonic acid, 69·2 per cent. of copper oxide and 5·2 per cent. of water, the chemical formula being $CuH_2O_2$, $2CuCO_3$. It is soluble in acids with effervescence. It has been employed in painting under the name of *Mountain Blue.*

## B.

**BARIUM CHLORIDE.**—Chemical formula, $BaCl_2$. It is the chloride of the metal barium; it crystallises in pearly crystals, having the composition $BaCl_2H_2O$, and easily soluble in water; the solution has a bitter taste. Barium chloride possesses poisonous properties. It is usually prepared by dissolving witherite, the native carbonate of barium, in hydrochloric acid, and crystallising out the salt. On heating, it melts, but is not decomposed. It is employed in the preparation of *blanc fixe* (precipitated barytes), and in the preparation of lake pigments from coal-tar colours, of which it is one of the best precipitants known.

**BARIUM CHROME.**—This pigment, also known as lemon chrome, is the chromate of barium, $BaCrO_4$; it is prepared by precipitating barium chloride with potassium chromate. It is not much used as a pigment, as its colouring power is but weak, and it has little covering power. It is permanent on exposure to the air.

**BARIUM SULPHATE.**—Chemical formula, $BaSO_4$. This important compound occurs naturally as the mineral barytes, which is very widely diffused, but is more particularly associated with lead ores, and is known by the lead miners of some localities as "lead bloom," while others call it "cawk". It is also generally known as heavy spar, on account of its high specific gravity. Barytes is found in a great variety of forms, sometimes as white opaque crystalline masses, at others as colourless crystalline masses, at others in a variegated form. It is largely employed as a pigment, for which purpose the natural mineral is ground and levigated; it is also employed as a source for the preparation of other barium compounds. It is quite insoluble in water, acids and alkalies. It is infusible and not altered on heating. Barium sulphate can also be prepared by adding sulphuric acid to a solution of a soluble barium salt, like the chloride or nitrate, when it is obtained as a fine white precipitate. This variety is commonly known as *blanc fixe*, and under that name is largely employed in the paper making industry. The specific gravity of barytes is 4·5 to 4·73.

**BARYTES** is the name given to the natural sulphate of barium. See *Barium Sulphate*.

**BEESWAX.**—This, the best known of the waxes and the typical representative of that group of substances, is the product of various species of insects belonging to the genus *apis*, which are found in every quarter of the globe. The insects secrete the wax, and employ it in the construction of what are called the "combs," which are the receptacles in which they in summer store the honey on which they live during the winter months of the year, when there are no flowers from which they may extract their food. The wax is obtained by melting the combs in water, and then allowing the molten wax to cool.

Beeswax has a yellow colour, varying somewhat in depth and tint ; it has a pleasant ethereal odour. The specific gravity is 0·960 to 0·962. It is insoluble in water, softens when slightly warmed, and melts at 68° C. (154° F.). It is soluble in boiling alcohol ; on cooling, a portion of the wax is deposited. It is slightly or only partially soluble in ether, turpentine and petroleum spirit. Chloroform is the best solvent for beeswax. Aqueous solutions of the caustic alkalies have little or no action on wax ; when boiled with alcoholic solutions it undergoes a kind of saponification. By exposure in thin layers to sun and air the colour of beeswax may be destroyed, and it is in this way that beeswax is usually bleached. Beeswax is a mixture of two bodies, *cerotic acid*, $C_{26}H_{53}COOH$, which is present usually to the extent of 12 per cent. The other constituent is *myricin*, which is an ethereal body, myricyl palmitate, having the formula $C_{15}H_{31}COOC_{30}H_{61}$, and is present to the extent of 88 per cent.

Beeswax is frequently adulterated ; the most common adulterant in use at present is ceresin, which is a semi-refined ozokerit ; this body is used because it more closely resembles beeswax in its granular appearance than any other substance. Besides this, paraffin wax, stearic acid, and other bodies have been used for this purpose.

The best method of testing the purity of beeswax is that devised by Hehner (*Analyst*, vol. viii., 1883, p. 16). Three grammes of the wax are weighed out in a flask of fair capacity, and heated with 50 c.c. of methylated spirit which has been purified by distillation over alkali. When a solution has been obtained a few cubic centimetres of an alcoholic solution of phenol-phthalein are added, and then the mass is titrated with an alcoholic solution of caustic potash of known strength, the mixture being kept well agitated while running in the potash solution. The end is reached when a permanent pink colouration is obtained. The volume of potash used is read off, and corresponds to the cerotic acid present in the wax. One cubic centimetre of potash of normal strength is equal to 0·41 of cerotic acid, the requisite calculations being made accordingly. Next, 50 c.c. of the alcoholic potash solution are run in and the mass boiled for an hour under a reflux condenser, the flask being shaken from time to time; this causes the saponification of the myricin; after being boiled the contents of the flask are titrated with standard acid, and the excess of potash used determined. From this the quantity of potash required to saponify the myricin is ascertained. One cubic centimetre of normal potash solution is equal to 0·676 gramme of myricin. The composition of pure beeswax has already been given. The addition of ceresin or paraffin wax reduces the total potash required for both the acid and the saponification of the myricin, the quantities of these as ascertained amounting to less than 100. The addition of stearic acid will increase the apparent proportion of cerotic acid, while the addition of Japan wax or stearin will increase the apparent proportion of myricin. From the results which are obtained it will be possible to determine the amount and kind of adulteration.

**BENZOIN.**—See *Gum Benzoin.*

**BENZOL OR BENZENE.**—This body is the lightest hydrocarbon obtained in the distillation of coal tar. During the distillation of coal tar a variety of products are obtained, the nature and proportion of which vary with the kind of tar being distilled. The first portion or fraction which comes over is a brown liquid, having a peculiar odour and a specific gravity ranging from 0·840 to 0·940; this is known as *first runnings*. It is of a most complex composition, and contains hydrocarbons of the paraffin and olefin series in small quantity, but its characteristic constituents are hydrocarbons of the benzene series: benzene, $C_6H_6$, toluene, $C_7H_8$, xylene, $C_8H_{10}$, cumene, $C_9H_{12}$, etc. In addition it contains small quantities of ammonia, aniline, toluidine, phenol, acetic acid, etc. This body is purified by first treating it with strong sulphuric acid, which separates out the basic constituents (ammonia aniline), the olefin hydrocarbons and certain other hydrocarbons which are soluble. After separating out the acid mass which is formed, the residual liquid is treated with a solution of caustic soda, which removes the acid bodies. Next the unacted-upon liquid is distilled, when it is divided into several fractions: the first, which comes over below a temperature of 100° C., is known as *benzol;* the second, which comes over below about 120° C., is known as *toluol;* while the remainder is run into another vessel to be distilled into what is known as *solvent naphtha.*

The benzol is redistilled and purified. Commercially, several grades of benzol are recognised: "90's Benzol" is the purest commercial benzol; when distilled 90 per cent. of it distils over below 100° C.; the great bulk of it is, therefore, benzene, while toluene is present to the extent of about 12 to 15 per cent. "50 90's Benzol" is the second quality of commercial benzols; when distilled it gives off 50 per cent. of its volume at a temperature of 100° C.; sometimes a lower grade still is met with, "30's Benzol," of which only 30 per cent. distils over below 100° C.

Benzol is employed for the preparation of nitro-benzol or mirbane, dinitro-benzol, aniline, etc., all of which are used in the manufacture of dyestuffs.

Benzene when pure is a water-white, very limpid liquid, of a specific gravity of 0·884, which varies a little with the origin of the sample; it boils at 80° C., a commercial pure benzene can be got, of which 95 to 98 per cent. will distil between 80° and 82° C. It is very volatile and highly inflammable, burning with a bright and smoky flame. It is insoluble in water, but readily dissolves in or mixes with alcohol, ether, turpentine, petroleum spirit, etc., while it is a powerful solvent for oils, fats, resins, etc. It is employed in the making of varnishes on account of its solvent action on resins.

When treated with nitric acid benzene is converted into nitro-benzene, $C_6H_5NO_2$, which has the odour of essential oil of almonds and is hence used as a perfume; heated with a mixture of nitric and sulphuric acids benzene is converted into dinitro-benzene, which is a solid body much used in the manufacture of explosives and as an intermediate product in the preparation of coal-tar colours. Alkalies have no action on benzene. Sulphuric acid has but little action; it has none in the cold, but by long-continued digestion it converts the benzene into benzene sulphonic acid, $C_6H_5SO_3H$, which forms a soluble salt with barium.

Benzol has been adulterated by adding petroleum products of various kinds; this addition may be detected by the reduction in specific gravity, by the fact that when treated with a mixture of nitric and sulphuric acids the whole of the sample is not converted into nitro products, which are heavier than water; these sink to the bottom when the mixture of acid, etc., is poured into water, while the unchanged petroleum separates and floats on the surface of the water.

Another plan of detecting petroleum products in commercial benzols is by means of the boiling points; benzol will not begin to boil below 80° C., while if any benzoline has been added, the adulterated sample will begin to boil at from 65° to 70° C. On the other hand, should petroleum burning oil have been added, nearly all the benzol will have come over below 100° C., while very little, if any, of the added oil will have come over; further, a temperature of something like 150° to 170° C. must be reached before all will have distilled over, which is higher than that of any of the commercial varieties of benzol.

Although the presence of added petroleum products to benzols is not difficult to detect, yet to ascertain the amount with any degree of certainty is very difficult, and there are no good methods for doing it; the test with nitric acid worked out quantitatively is about the best.

**BENZOLINE** is the name given in this country to a light spirit obtained from American petroleum. The crude petroleum is run into tanks, and any dirt allowed to settle out; it is then allowed to run into large iron stills holding from 5,000 to 10,000 gallons, and subjected to distillation, either with or without the aid of superheated steam. The portion which first comes over is collected; it has a specific gravity of 0·705, and is known as *light naphtha*. A second fraction of the distillate, having a gravity of 0·705 to 0·744 is collected as *heavy naphtha*. This portion is again distilled, and fractionated into *benzoline* or *benzine* and other products. The benzoline or benzine is made in several qualities having gravities of 0·730 to 0·760. It is a limpid water-white spirit, taking fire immediately on a flame being applied to it. It begins to distil at a temperature of 65° C., although samples vary very much; heavy benzolines may be met with which will not distil below 100° C. A sample tested by the author distilled at the following rate:—

| | | | |
|---|---|---|---|
| 3 | per cent. | below | 70° C. |
| 12 | „ | „ | 75° C. |
| 24 | „ | „ | 80° C. |
| 30 | „ | „ | 85° C. |
| 49 | „ | „ | 90° C. |
| 55 | „ | „ | 95° C. |
| 66 | „ | „ | 100° C. |
| 72 | „ | „ | 105° C. |
| 81 | „ | „ | 110° C. |
| 92 | „ | „ | 120° C. |

Benzoline is a mixture of hydrocarbons, of low molecular weight and boiling points, belonging to the paraffin and olefin series of hydrocarbons. These bodies are not acted upon by either acids or alkalies in the cold ; when heated with nitric acid they undergo a certain amount of oxidation ; hot aqueous solutions of alkalies have no action in them. It has little action on bromine or iodine.

Exposed to the air benzoline is completely volatile. It is a good solvent for oils, fats, waxes, many resins, etc., and is employed in oil refining and varnish making, on account of its solvent properties.

Benzoline closely resembles shale naphtha in its properties and composition, and it is difficult to distinguish the two bodies. See also *Gasoline*, *Petroleum Naphtha*, *Shale Naphtha.*

**BERLIN BLUE,** a name sometimes given to *Prussian Blue* (which see), on account of its having been first made by a Berlin colour maker.

**BICHROMATE OF POTASH,** commonly known as *bichrome*, is a compound of chromic acid and potash, having the chemical formula, $K_2Cr_2O_7$, which is very much used in colour making and in various other chemical operations. It is manufactured from chrome iron ore, a mineral containing oxide of iron in combination with oxide of chrome. This mineral is fused in a furnace with potash, lime and saltpetre, whereby it is decomposed, and chromate of potash is formed. This is separated from the oxide of iron and lime by lixiviating with water. To the solution sulphuric acid is added whereby the potassium chromate is converted into the bichromate, while any lime which may have passed into solution is precipitated out. On clarifying the liquid and crystallising, bichromate of potash separates out in the form of orange red transparent crystals of large size. The specific gravity is 2·692. It has a peculiarly bitter, metallic taste. It contains 31·86 per cent. of potassium oxide, $K_2O$, and 68·14 per cent. of chromic acid, $CrO_3$. It is but slightly soluble in cold water, 100 parts of which will dissolve 4·6 parts at 0° C. It is much more freely soluble in boiling water, 100 parts of which will dissolve 94·1 parts of the salt. A solution of potassium bichromate at 15° C. (60° F.) has a specific gravity of 1·032, and contains 6·49 per cent. of the salt.

When heated it is decomposed, oxygen is evolved, and a mixture of oxides of potassium and chromium is obtained.

Heated with hydrochloric acid gas chlorine is evolved and a green solution is obtained, which contains chromium and potassium chlorides. Heated with strong sulphuric acid oxygen is evolved, and a green or violet solution is obtained containing the sulphates of chromium and potassium. On crystallising this, fine deep ruby crystals of chrome alum are obtained. On adding sulphuric acid to a strong solution of potassium bichromate, chromic acid separates out in the form of deep red crystals of the formula $CrO_3$. Bichromate of potash is a powerful oxidising agent, especially in the presence of acids; it will convert anthracene into anthraquinone, alcohol into acetic acid, and it exerts an oxidising action on many other organic bodies.

Potassium bichromate is largely employed in the manufacture of chrome yellow, chrome orange, and all chrome pigments; it is used in woollen dyeing for the mordanting of the woollen yarns, cloths, etc.; for dyeing with alizarine and similar mordant dyes; it is used as a bleaching agent for tallow, palm oil, and other fats in conjunction with sulphuric acid; it is employed in tanning leather, and has many other uses.

**BICHROMATE OF SODA,** $Na_2Cr_2O_7$, is obtained by furnacing a mixture of chrome iron ore, soda ash and chalk, lixiviating the product with water and boiling the solution down until it crystallises, when yellow crystals of sodium chromate are obtained. To prepare the bichromate from these sulphuric acid is added, the sodium sulphate allowed to crystallise out, and the solution of sodium bichromate evaporated down to dryness. It can be obtained in the form of crystals containing two molecules of water of crystallisation. The commercial bichromate is usually in the form of a coarse powder, containing 83 to 85 per cent. of actual bichromate of soda, so that it varies somewhat in quality. It is hygroscopic, absorbing water from the atmosphere and passing into a syrupy solution; this property is a disadvantage to its use for various purposes as it greatly increases the difficulties of storing it.

Sodium bichromate is very readily soluble in water; 100 parts of water at 0° C. will dissolve 107 parts of the anhydrous salt; at 100° C. it will dissolve 163 parts of the salt; in this respect of solubility the sodium compound has a great advantage over the potassium compound, but at the same time it makes it more difficult to obtain pure.

Solutions of sodium bichromate have the following specific gravities according to the quantity of salt contained in them:—

| Per Cent. $Na_2Cr_2O_7$. | Specific Gravity. | Per Cent. $Na_2Cr_2O_7$. | Specific Gravity. | Per Cent. $Na_2Cr_2O_7$. | Specific Gravity. |
|---|---|---|---|---|---|
| 1 | 1·007 | 18 | 1·127 | 35 | 1·245 |
| 2 | 1·014 | 19 | 1·134 | 36 | 1·252 |
| 3 | 1·021 | 20 | 1·141 | 37 | 1·259 |
| 4 | 1·028 | 21 | 1·147 | 38 | 1·266 |
| 5 | 1·035 | 22 | 1·153 | 39 | 1·273 |
| 6 | 1·042 | 23 | 1·159 | 40 | 1·280 |
| 7 | 1·049 | 24 | 1·165 | 41 | 1·287 |
| 8 | 1·057 | 25 | 1·171 | 42 | 1·294 |
| 9 | 1·064 | 26 | 1·178 | 43 | 1·300 |
| 10 | 1·071 | 27 | 1·185 | 44 | 1·307 |
| 11 | 1·078 | 28 | 1·193 | 45 | 1·313 |
| 12 | 1·085 | 29 | 1·201 | 46 | 1·319 |
| 13 | 1·092 | 30 | 1·208 | 47 | 1·325 |
| 14 | 1·099 | 31 | 1·216 | 48 | 1·330 |
| 15 | 1·105 | 32 | 1·224 | 49 | 1·336 |
| 16 | 1·113 | 33 | 1·231 | 50 | 1·343 |
| 17 | 1·120 | 34 | 1·238 | | |

Bichromate of soda possesses similar properties to the bichromate of potash, is affected by heat, acids and alkalies in exactly the same way, and may be employed for the same purposes.

**BISTRE** is the name given to a brown pigment prepared from the soot of wood fires ; it consists essentially of carbon mixed with some empyreumatic material. It is not much used.

**BITUMEN OF JUDEA** is the name given to the variety of *Asphaltum* (which see) imported from Syria and the East.

**BLACK ANTIMONY.**—The name given to the powdered native antimony sulphide $Sb_2S_3$. It is a black, shiny powder, much employed in medicine and for the preparation of antimony compounds ; it is soluble in hot hydrochloric acid, with the evolution of sulphuretted hydrogen and the formation of a solution of antimony chloride.

**BLACK LAKES** are prepared from logwood by precipitating a decoction of the dyewood with solutions of copper sulphate and ferrous sulphate or bichromate of potash. They are essentially copper-iron or chrome lakes of the colouring principle (haematoxylin) of logwood. They are now almost, if not quite, obsolete.

**BLANC FIXE** is the name given to the barium sulphate prepared artificially by precipitating a soluble barium salt by means of sulphuric acid or a sulphate. It is obtained as a bye-product in the manufacture of many dyers' chemicals, such as alumina sulphocyanide, etc.; it also enters into the composition of some pigments, Orr's white, various lakes, etc., being precipitated along with the principal or characteristic ingredients. It is a fine white pigment, rather heavy, but possessing considerable opacity and covering power; it is exceedingly white in colour. It is employed in paper making, paper staining and other purposes. Its properties have already been detailed under the heading *Barium Sulphate.*

**BLEACHING POWDER** is a compound of lime and chlorine prepared by passing chlorine gas over dry slaked lime. Its chemical composition is represented by the formula $CaOCl_2$. It owes its value for industrial purposes to the fact that weak acids, even carbonic acid, decompose it, with the liberation of chlorine, which can then exert its bleaching or oxidising action. The reaction is expressed in the following equation:—

$$CaOCl_2 + H_2SO_4 = CaSO_4 + Cl_2 + H_2O.$$

Generally the whole of the chlorine contained in commercial bleaching powder, or *chloride of lime*, as it is often called, is not liberated as free chlorine. As it is only this portion which can exert any bleaching effect, it has come to be known as *available chlorine*, and good bleaching powder contains from 35 to 36 per cent. of it.

Bleaching powder is more or less soluble in water. The following table gives the specific gravity of solutions of various gravities:—

### STRENGTH OF BLEACHING POWDER SOLUTIONS.

(*After Professor Lunge.*)

| Specific Gravity. | Degrees Twaddell. | Available Chlorine. | |
|---|---|---|---|
| | | Grams per Litre. | Grains per Gallon. |
| 1·1155 | 23·1 | 71·79 | 5025·3 |
| 1·1150 | 23 | 71·50 | 5005·0 |
| 1·1105 | 22·1 | 68·66 | 4806·2 |
| 1·1100 | 22 | 68·00 | 4760·0 |
| 1·1060 | 21·2 | 65·33 | 4573·1 |
| 1·1050 | 21·0 | 64·50 | 4515·0 |
| 1·1000 | 20 | 61·17 | 4281·9 |
| 1·0950 | 19 | 58·33 | 4083·1 |
| 1·0900 | 18 | 55·18 | 3862·6 |
| 1·0850 | 17 | 52·27 | 3658·9 |
| 1·0800 | 16 | 48·96 | 3427·2 |
| 1·0750 | 15 | 45·70 | 3199·0 |
| 1·0700 | 14 | 42·31 | 2961·7 |
| 1·0650 | 13 | 38·71 | 2709·7 |
| 1·0600 | 12 | 35·81 | 2506·7 |
| 1·0550 | 11 | 32·68 | 2287·6 |
| 1·0500 | 10 | 29·41 | 2058·7 |
| 1·0450 | 9 | 26·62 | 1863·4 |
| 1·0400 | 8 | 23·75 | 1662·5 |
| 1·0350 | 7 | 20·44 | 1430·8 |
| 1·0300 | 6 | 17·36 | 1215·2 |
| 1·0250 | 5 | 14·47 | 1012·9 |
| 1·0200 | 4 | 11·44 | 798·7 |
| 1·0150 | 3 | 8·48 | 593·6 |
| 1·0100 | 2 | 5·58 | 390·6 |
| 1·0050 | 1 | 2·71 | 189·7 |
| 1·0025 | ½ | 1·40 | 98·0 |

The last column is not given by Lunge, but has been calculated from the figures in the third column, which also represent the number of lb. of available chlorine in 100 gallons of the solution. See Tailfer's *Treatise on Bleaching*.

**BLUE VERDITER** is a basic carbonate of copper prepared by precipitating solutions of copper salts by means of sodium carbonate, and treating the precipitate with a little caustic soda. It is rarely used now, its place being taken by ultramarine, cobalt blue and blues prepared from Prussian blue, which are much more permanent. Blue verditer is of a pale blue colour, and has very little body and colouring power; it is not permanent, fading on exposure to light and air, while it is liable to alteration by admixture with other pigments. It is completely soluble in hydrochloric acid, with some effervescence. On passing a current of sulphuretted hydrogen gas, through this solution, a black precipitate of copper sulphide will be obtained. The filtrate from this precipitate should give no further precipitate with ammonia, ammonium sulphide or ammonium carbonate.

**BOILED OIL** is the name given to linseed oil which has been heated to about 500° F. for some hours along with litharge, manganese oxide or other drier. See *Linseed Oil*.

**BONE BLACK.**—This product is made from bones by calcining them in closed vessels in a suitable furnace. During the operation some volatile matter is given off, which, when condensed, forms an oily product known generally as *Dippel's Oil*, and having a powerful and somewhat unpleasant odour. The residue in the vessel is allowed to cool, and, when cold, is ground up either into grains for use in decolourising sugar, glycerine, etc., or into powder when it is used as a pigment or in making blacking.

The colouring principle of bone black is essentially carbon derived from the animal matter in the bones; in addition to the carbon there is also present a large percentage of mineral matter, which consists chiefly of phosphate and carbonate of lime. The following analysis of three samples of bone black will show the average composition:—

| | Per Cent.<br>1. | Per Cent.<br>2. | Per Cent.<br>3. |
|---|---|---|---|
| Water . . . | 6·09 | 7·14 | 6·55 |
| Ash or mineral matter | 76·67 | 77·65 | 73·04 |
| Carbon . . . | 17·24 | 15·21 | 20·41 |

Of the mineral matter 60 per cent. is phosphate of lime, the rest being chiefly carbonate of lime with traces of iron, lime and alumina. On being heated to bright redness, the carbon in the bone black burns off and the mineral matter is left behind; this ought to have a greyish colour, a reddish tint indicating the presence of iron.

Bone black is chiefly used for decolourising sugar, its efficacy depending partly on its condition and partly on the proportion of carbon it contains, although it is not certain on what feature in bone black its decolourising power depends.

As a pigment it is employed on account of its colour and the fact that it mixes freely with vehicles of various kinds. In blacking making the colour is important, as is also the proportion of mineral matter it contains, as this to some extent neutralises the acid employed in the manufacture of the blacking and helps to make a more pasty mass.

An analysis of bone black may be made in the following manner:—

*Moisture.*—Two grammes are weighed out between a pair of watch glasses and then kept in a hot oven until no further loss of weight occurs. Three per cent. is what good char for sugar treatment should contain, while for other kinds of bone black the moisture may reach 7 per cent.

*Ash or Mineral Matter.*—Two grammes are weighed into a crucible and then heated over a Bunsen burner until all the carbonaceous matter is burnt off, then the residue is weighed. The carbon may be taken by difference from the two results obtained.

If a more extended examination is required, then the following method may be adopted:—

Moisture is determined as before.

For *Carbon, Iron, Calcium Sulphate and Insoluble Ash.*—Weigh 2 grammes of the sample, which has been previously ground to a fine powder, and heat with hydrochloric acid and water for about half an hour; the liquid is allowed to stand and the clear liquor decanted through a Gooch filter fitted with an asbestos plug; the residue in the beaker is washed with water, the washings being also passed through the crucible; finally the whole is filtered through the crucible, and its contents are now placed in a hot air oven and dried, when it is weighed; the increase in weight over the empty crucible being the insoluble ash and the carbon. The crucible is now heated to redness and the carbon burnt off, when it is again weighed; the loss of weight represents the carbon, the difference being the insoluble ash.

The solution will contain iron, alumina, calcium chloride, calcium phosphate and calcium sulphate. Ammonia is added to it until it is nearly neutral, and then ammonium acetate in slight excess; when it is boiled there will be obtained a precipitate of iron and aluminium phosphates, which is filtered off. To the solution is added barium chloride, which will form a precipitate of barium sulphate if there be any calcium sulphate present. This precipitate is filtered off, washed, dried, and after being burned in a crucible, weighed; by multiplying the weight by 0·583 the equivalent weight of calcium sulphate is obtained; if this body is present in notable amount it must have been added, as it is not a normal constituent of bone black.

The precipitates of iron and alumina phosphates may be dissolved in a little nitric acid, some ammonium molybdate added and the mixture boiled, when the phosphoric acid is thrown down as ammonium phospho-molybdate which may be filtered off; to the filtrate caustic soda is added in slight excess and the mixture boiled; it is now filtered, and after thoroughly washing the precipitate of iron oxide which is obtained, the latter is dried, burned in a weighed crucible and weighed. From the filtrate the alumina may be precipitated by adding, first, hydrochloric acid, then ammonia in slight excess, filtering, washing, drying and burning; the precipitate of alumina thus obtained is weighed.

The calcium carbonate may be determined by ascertaining the quantity of carbonic acid in the sample; this may be done either in a Lunge's nitrometer or in a carbonic acid apparatus.

The ammonium molybdate precipitate can be dissolved in a little hydrochloric acid and the phosphoric acid it contains precipitated as ammonium-magnesium phosphate by adding ammonia and magnesium sulphate; this precipitate is filtered off, washed with water containing a little ammonia, then dried, burnt, and the residual magnesium pyrophosphate weighed; from it the proportion of calcium phosphate in the bone black can be calculated. For details of these various tests reference should be made to some standard work on Quantitative Chemical Analysis.

The physical condition of the black is as important as, or perhaps even more so than, its chemical composition. The bone black for sugar refining should not be too fine. The proportion of fine black may be ascertained by sieving through sieves of a certain mesh. For pigment purposes the black should be fine and of good colour, which points may be ascertained by a comparative examination with a standard sample of bone black of good quality.

Bone black is sometimes adulterated with cheaper blacks, such as animal black, lamp black, etc.; such additions may be detected by their reducing the proportion of mineral matter contained in the sample and also altering its composition in some cases.

Reference may be made to the articles on *Animal Black*, *Lamp Black* and other blacks, and to that on *Testing Pigments*. See Lambert's *Bone Products and Manures*.

**BONE BROWN,** like bone black, is prepared by calcining bones, but the process is not carried so far as for bone black. In composition it resembles bone black, but contains more carbonaceous matter. It is not much used.

**BORACIC ACID or BORIC ACID.**—This substance is found free in nature in most if not all volcanic districts. In Tuscany the vapours or gases which are found issuing from the earth are charged with the vapour of boracic acid, which is also found dissolved in the water of the small lakes which abound in this district. Boracic acid is also found in the form of metallic salts (borates) in many places, the most important of these salts being tincal (crude borax) and boracite, which are sodium compounds, and boronatrocalcite, which is a double salt of calcium and sodium. Crude boracic acid is obtained from the gases or *soffioni*, as they are called, of Tuscany, by causing them to pass through water, which dissolves the saline matters carried by the gases; the solution so obtained is then evaporated down, during which operation some calcium sulphate and other slightly soluble salts separate out, until a specific gravity of 1·07 is obtained, then it is run into crystalling pans, when the boracic acid separates out. This boracic acid is far from pure, as will be seen from the following analysis :—

| | Per Cent. |
|---|---|
| Boric acid | 76·5 |
| Ferric sulphate | 0·4 |
| Aluminium sulphate | 0·3 |
| Calcium sulphate and insoluble matter | 1·0 |
| Magnesium sulphate | 2·6 |
| Ammonium sulphate | 8·5 |
| Alkaline sulphates | 1·3 |
| Silica, sulphuric acid | 2·7 |
| Water | 6·6 |

The boracic acid is purified by re-solution in water and recrystallisation. Pure boracic acid may also be obtained by dissolving 3 parts of borax in 12 parts of boiling water, and adding 1 part of sulphuric acid and crystallising it from the solution. Boracic or boric acid forms white, tabular, pearly looking crystals of small size, which are soft to the touch. The specific gravity is 1·434. They are not freely soluble in water, 1 part requiring 25·7 parts of water at the ordinary temperature, and nearly 3 parts at the boiling point. The presence of certain bodies such as tartaric acid materially increases the solubility of boracic acid in water. It is soluble in alcohol and many oils. The alcoholic solution burns with a green flame, especially if a little hydrochloric acid be added to it. Heated to 100° C. boric acid loses some of its water, and is converted into metaboric acid, while further heating to 160° or 170° converts it into pyroboric acid, and on heating to a red heat it parts with all its water, and is converted into boric anhydride. The relationship of these acids is shown in the formulæ :—

| | |
|---|---|
| Orthoboric acid | $H_3BO_3$ |
| Metaboric acid | $H_2B_2O_4$ |
| Pyroboric acid | $H_2B_4O_7$ |
| Boric anhydride | $B_2O_3$ |

Boracic acid is employed in glazing porcelain, in the manufacture of glass, in the preparation of Guignet's green and other pigments, in the manufacture of borax, as an antiseptic, and in other ways.

**BORATE OF LEAD** is employed as a drier for oils and paints. See *Lead Borate*.

**BORATE OF MANGANESE** is employed as a drier for paints and varnishes. See *Manganese Borate*.

**BORAX.**—The most important compound of boric acid is borax, variously named biborate of soda and sodium dimetaborate, which occurs in prismatic crystals having the formula $Na_2B_4O_7$, $10H_2O$. Borax is made from boric acid by adding sodium carbonate to a solution of it and then crystallising out the borax which forms. Borax is also obtained from the natural borax found in Californian lakes by re-solution and crystallisation. Borax occurs in the form of large prismatic transparent crystals, as also in the form of powder. It effloresces slightly when exposed to the air. The specific gravity is 1·75. It has a sweet alkaline taste. It is soluble in water to the extent of 3 parts in 100 of water at the ordinary temperature, while at the boiling point 100 of water will dissolve 200 of borax. The aqueous solution has very slightly alkaline properties, and will turn the colour of a solution of turmeric brown; on adding a little sulphuric acid to the coloured solution the yellow colour is restored; an excess of sulphuric acid, however, causes the liberation of boric acid, which gives a red brown colouration with the turmeric solution. When borax is heated it swells up very much, and when the temperature reaches a red heat it fuses and forms a glassy mass.

Borax possesses many curious properties ; its solutions appear to possess alkaline properties ; it dissolves shellac, forms emulsions with oils and resins, and dissolves various organic acids like gallic, benzoic, tartaric and citric acids. With various metallic salts it yields precipitates of the borates of the metals.

It is employed in the manufacture of pottery, glass, enamels, in medicine, etc.

The detection of borax, or of boric acid in any composition into which it enters, is by no means easy. The two best tests are the brown colouration which boracic acid gives with turmeric and the green colour with which alcoholic solutions of boracic acid burn.

The compound to be tested is mixed with sulphuric acid, and the mixture treated with alcohol to extract the boracic acid which has been liberated ; on applying a light to this solution it will burn with a green flame, if there be any boracic acid in it. The solution will also give a brown red colouration with an alcoholic solution of turmeric. By distilling a mixture of a borate with sulphuric acid and alcohol the boracic acid comes off in the form of a volatile compound with the alcohol, and may be recognised in the distillate by the two tests given above ; this reaction may be taken advantage of to determine the amount of boracic acid, or of its compounds, present in a mixture.

**BRAZIL WOOD** is the wood of a tree known as *Cæsalpinia braziliensis*, found growing very largely in Brazil and other countries of South America. It is the best variety of the red dyewoods, and is employed in dyeing reds on wool and other fabrics with the aid of alumina and chrome mordants. It is also employed in the preparation of rose pink for painting. The colouring principle of Brazil wood is a body named *brazilin*, to which the formula $C_{22}H_{18}O_7$ has been given. It can be obtained in crystals, which are soluble in water, alcohol, ether, etc. On exposure to the air they absorb oxygen and pass into brazilein. Strong oxidising agents convert brazilin into picric acid.

*Brazilein*, $C_{22}H_{16}O_7$, is produced by the oxidation of brazilin, and is a dyestuff dyeing wool and other fibres in bright shades superior to those which can be got from the dyewood itself. Brazilin is colourless, and possesses no dyeing power at all; it is only when oxidised into brazilein that it acquires dyeing properties.

**BREMEN BLUE** is a basic carbonate of copper made by precipitating copper sulphate with sodium carbonate, and then treating the product with caustic soda, or by treating metallic copper with a solution of salt or ammonium chloride whereby it is converted into a basic chloride of copper, and then treating this with caustic soda. Blue verditer is a similar pigment. Bremen blue is soluble in acids; on adding ammonia a deep blue solution is obtained, a reaction which is highly characteristic of copper. Sulphuretted hydrogen throws down a black precipitate of sulphide of copper. A solution of potassium ferrocyanide throws down from a neutral solution a brown precipitate of ferrocyanide of copper. Bremen blue is now rarely used.

**BREMEN GREEN** is a similar pigment to the Bremen blue, and has practically the same properties. It has gone out of use.

**BRIGHTON GREEN** was the name given to a pigment made by grinding together acetate of lead, sulphate of copper and whiting. It has become obsolete.

**BRILLIANT SCARLET** is the name given to the scarlet iodide of mercury prepared by adding a solution of iodide of potassium to one of chloride of mercury. It is a very bright scarlet colour, but is very fugitive.

**BRITISH GUM or DEXTRINE.**—This product is prepared by heating starch to from 212° to 275° C. for some hours in iron drums, or by heating starch paste with a little acid for some hours; the former plan is that which is mostly in use in this country, the latter the one adopted on the Continent. By either process a product is obtained which has a yellow to brown colour, and a sweet taste. It is soluble in water, forming a thick viscid fluid possessing strongly adhesive properties, for which reasons it is most valued. Dextrine when pure is quite white, tasteless and inodorous; commercial dextrines vary considerably in colour. "White" is of a pale yellow colour. Generally it is not completely soluble in water, leaving a slight residue of unchanged starch; its solutions give the blue iodide reaction characteristic of starch. It gives a thick viscid solution which does not possess any strong adhesive properties. "Canary" has a bright yellow colour. It is rather more soluble than the latter, and does not give a blue colouration with iodine; its solutions have strong adhesive properties. This is the variety of dextrine chiefly used for gumming paper, etc. "Yellow" dextrine has a dark colour, and gives a thick mucilaginous solution; it is used only for very common purposes. When pure, solutions of dextrine give only a brownish colouration with iodine, but many of the commercial varieties give a faint blue colour, showing that they contain unchanged starch. Boiled with Fehling's solution (tartrate of potash and copper) a red precipitate of cuprous oxide is obtained. Dextrine requires about its own weight of water for solution. When dilute solutions are boiled for some time they lose their adhesive properties, the dextrine having become converted into sugar; this change is hastened if a little acid be added to the solutions, the particular variety of sugar formed being that known as dextrose, which has a reducing action on Fehling's solution.

Dextrines are used for a variety of purposes, for gumming paper, envelopes, etc., for medicinal purposes, for thickening calico printers' colours, in stiffening crape, lace, etc., finishing cotton, and other uses. Commercial dextrines should be examined for colour, proportion of insoluble matter, thickness or viscosity and adhesiveness of the solutions they give, the presence of free acid, the absence of mineral matter, the proportion of water they contain, to ascertain whether they are suitable for the particular use to which they are going to be put.

**BRUNSWICK GREEN.**—This name used to be applied to a pigment made from oxychloride of copper. It is now, however, invariably applied to a mixture of barytes, chrome yellow and Prussian blue. Brunswick green is made in four standard shades known as "pale," "medium," "deep," and "extra deep," varying in tint from a yellow green to a deep blue green. It must not, however, be assumed that the "deep" tint of one maker will correspond with the "deep" tint of another maker. These pigments work well in either oil or water, in the former especially; they have good body or covering power, and strong colouring or staining properties. With but few exceptions they can be mixed with all other pigments without undergoing or bringing about any change. They ought not to be mixed with any pigments containing sulphur, as this may lead to the production of the black sulphide of lead by acting on the chrome yellow contained in the pigment.

Acids have little action on the colour, but alkalies turn it red owing to their action on the blue constituent, forming oxide of iron, and on the yellow, forming the basic red chromate of lead.

The Brunswick greens are fairly permanent when exposed to light and air; the yellow in them tends to fade somewhat, but the blue is permanent.

Brunswick greens should be assayed for their depth and brilliance of colour, covering power and colouring power by the usual methods. It is rarely that an analysis of Brunswick greens is required, but when that is the case the following scheme, described by Browne in the *Chemical News*, 31st December, 1886, may be employed:—

Weigh out 2 grammes of the green and treat with 28 to 30 c.c. of strong hydrochloric acid at the boil for about ten minutes, then, whilst still hot, filter and wash well with boiling water, adding the wash waters to the filtrate.

The residue consists of barytes and Prussian blue. It is strongly heated over the Bunsen burner until the blue is decomposed and a red residue of barytes and oxide of iron is obtained. This is allowed to cool, and is then weighed. It is next treated with a mixture of nitric and hydrochloric acids, boiled well, then diluted with water and filtered. The residue is dried, heated over the Bunsen burner in a weighed crucible, and, after being allowed to cool, is weighed. The weight of the barytes is thus obtained. The difference in the two weights which have been obtained gives the proportion of oxide of iron, and this, multiplied by 2·212, gives the weight of the Prussian blue in the sample.

The filtrate from the blue and barytes first obtained is nearly neutralised with ammonia, and a current of sulphuretted hydrogen gas is passed through. This throws down the lead as lead sulphide; the precipitate is collected on a filter and washed, the washings being added to the filtrate. The precipitate is treated with strong nitric acid, and boiled down to a small bulk; a little sulphuric acid is then added, and the mixture heated until acid fumes begin to make their appearance, when it is allowed to cool; water and a little alcohol is then added, and the mixture filtered; the precipitate of lead sulphate which is obtained is then dried and weighed. This gives the total quantity of lead in the sample. It may be present both as sulphate and as chromate.

*Filtrate from the Lead Sulphate.*—This contains the chromium, and occasionally a little iron. As the method of analysis depends upon whether this constituent is present or absent, it is necessary to test for it, and this is done by placing a drop of the liquor on a piece of paper moistened with potassium ferrocyanide solution; if iron be present a blue stain will be produced. In this case the method of working is as follows: Boil the solution with nitric acid and potassium chlorate until a clear yellow solution is obtained, then add ammonia to precipitate the iron, filter off, wash, dry and weigh. This weight is to be added to that of the iron found above. Take the filtrate from the iron precipitate, boil down to a small bulk, add some strong hydrochloric acid and a little alcohol, and boil until the colour of the solution becomes a clear green. This is effected by adding a little more acid and alcohol. To the solution is added ammonia in excess, the mixture being boiled until it forms or gives a colourless filtrate; the precipitate which forms is one of chromium hydroxide; this is filtered off, well washed with water, dried and weighed; the weight multiplied by 4·241 gives the weight of lead chromate or chrome yellow in the sample. If no iron is present in the filtrate from the lead sulphide it is boiled, ammonia in slight excess is added, and the precipitate of chromium hydroxide which is obtained is treated as in the last method.

Any lead sulphate is determined by taking 2 grammes of the green, boiling with strong hydrochloric acid, and filtering whilst still hot, then add barium chloride to the boiling filtrate, filter, wash the precipitate of barium sulphate well with boiling water, then dry, ignite and weigh it. The weight of barium sulphate multiplied by 1·3 gives that of the lead sulphate present in the green. The difference between this amount and that previously found represents the lead present in other forms of the green.

It is always advisable to make a qualitative analysis of a sample of green before making a quantitative analysis to ascertain the nature of the constituents present, and, if necessary, the analytical scheme should be modified according to the results of the qualitative analysis.

The following table shows the composition of a representative make of Brunswick greens examined by the author :—

ANALYSIS OF BRUNSWICK GREENS.

| | Pale. | Middle. | Deep. | Extra Deep. |
|---|---|---|---|---|
| Water . . . . . . . . | 1·20 | 0·86 | 1·06 | 0·80 |
| Barytes . . . . . . | 71·74 | 71·64 | 72·16 | 72·40 |
| Gypsum . . . . . . | 2·64 | traces | traces | — |
| Prussian blue . . . | 0·96 | 1·46 | 3·64 | 6·96 |
| Chrome yellow . . . | 15·29 | 24·73 | 19·46 | 17·69 |
| Lead sulphate . . . | 8·17 | 1·31 | 3·68 | 2·15 |

**BURMESE LACQUER** is the sap of a tree which grows in Burmah. When applied to articles it dries and leaves a glossy coat behind. In all essential particulars it resembles Japan lacquer. See *Japanese Lacquer*. Burmese lacquer is not imported into this country.

**BURNT SIENNA** is a pigment obtained by heating *Sienna*, which see.

**BURNT UMBER** is a deep brown pigment obtained by heating umber. See *Umbers*.

**BUTTON LAC** is the name given to that form of lac which is imported in the form of round flakes of about 1 inch or 1¼ inches in circumference. See *Lac*.

## C.

**CADMIUM YELLOW** is the sulphide of the metal cadmium, prepared by passing a current of sulphuretted hydrogen gas through a solution of a cadmium salt. It has a composition corresponding to the formula $CdS$. Pure cadmium yellow is one of the most permanent pigments known; it mixes with nearly all other pigments without being affected by or altering them; it is unaltered by exposure to light and air. It works well in all vehicles, possesses good body or covering power and fairly strong colouring powers. Although its action on pigments is *nil*, or but slight, it is not advisable to mix it with chrome yellow, emerald green, or other pigments containing lead or copper, as these are liable to be turned black by the sulphur in the cadmium yellow forming the black sulphide of lead or copper, as the case may be. Very pale shades of cadmium yellow are sometimes offered; these contain free sulphur, and are rather liable to become decolourised on exposure to light and air. Cadmium yellow should be completely soluble in strong hydrochloric acid, forming colourless solutions of cadmium chloride—sulphuretted hydrogen being at the same time evolved. On passing a current of sulphuretted hydrogen gas through the acid solution a yellow precipitate of cadmium sulphide should be obtained; the filtrate from this should give no further precipitates on addition of ammonia, ammonium sulphide and ammonium oxalate. Cadmium yellow is rarely adulterated, the most common additions being zinc chrome, arsenic yellow or chrome yellow, the presence of which can be readily detected. The tests for these pigments will be found under the respective heads.

Cadmium yellow is entirely used by artists, with whom it is a favourite pigment; it is rather too expensive for house painters and decorators.

**CALCINED BONE** is made by grinding bones into small pieces and heating to a red heat in a suitable furnace until all the carbonaceous matter is burned off. It is generally sold in the form of a greyish-white powder, insoluble in water, soluble in hydrochloric acid with a slight effervescence, owing to the evolution of carbonic acid gas from the calcium carbonate it contains; there may be a small quantity of insoluble matter in some samples of calcined bones. Calcined bones consist chiefly of calcium phosphate and calcium carbonate. An analysis of a sample of commercial calcined bones made by the author showed it to contain:—

1·35 per cent. of water.
3·50 ,, ,, insoluble matter.
12·53 ,, ,, calcium carbonate.
82·62 ,, ,, calcium phosphate.

Calcined bone is largely employed in the manufacture of porcelain, entering into the composition of the body, in which it plays the part of a binding agent; when the porcelain is fired the phosphate of calcium contained in the calcined bone fuses; and then envelops the other portions of the porcelain which do not fuse, and so binds them all together. On this account it is evident the value of the calcined bone depends upon the proportion of calcium phosphate it contains, and the more there is of this, the more valuable the product.

Calcined bone may be analysed in the following manner: Two grammes are dissolved in hydrochloric acid, any insoluble matter they contain is filtered off, and its weight determined in the usual way; to the filtrate, ammonia is added; this throws down all the calcium phosphate in the sample; and this is filtered off, dried, ignited and weighed in the usual manner. Usually this will be from 80 to 84 per cent. in weight. On adding a solution of ammonium oxalate to the filtrate from the ammonia precipitate, the lime, which is present as carbonate in the calcined bones, is thrown down as oxalate; this is filtered off, washed, dried, heated in a crucible until it is all converted to carbonate and then weighed. If there be any alumina in the sample it will be thrown down and weighed with the calcium phosphate; there is, however, but little alumina present in calcined bones.

**CALAMINE** is the name given to the natural carbonate of zinc, which is found in small quantities in various localities: Alston in Cumberland, Mendip Hills in Somersetshire, Matlock in Derbyshire, and elsewhere. It is not used to any large extent.

**CALEDONIAN WHITE LEAD.**—Under this name has been sold a lead white pigment, consisting principally of sulphate of lead, oxide of zinc and barytes, prepared by Mr. Hannay's patent process.

**CANDLE BLACK.**—Under this name has been sold a fine quality of lamp black.

**CAPPAGH BROWN** is the name given to a fine brown pigment found at the Cappagh Mines of Lord Audley, about ten miles from Skibbereen in County Cork, Ireland. The following analysis shows the composition of this brown :—

| | Per Cent. |
|---|---|
| Water given off at 100° C. | 18·7 |
| Water given off at a red heat | 11·6 |
| Ferric oxide, $Fe_2O_3$ | 34·4 |
| Manganese oxide, $MnO_2$ | 27·2 |
| Alumina, $Al_2O_3$ | 2·6 |
| Lime, CaO | 1·1 |
| Magnesia, MgO | trace |
| Silicia, $SiO_2$ | 4·6 |
| Phosphoric acid, $P_2O_5$ | 0·4 |

(Church, *Chemistry of Paints and Painting*, p. 206.)

Cappagh brown works well in both oil and water, and is a permanent pigment. On heating it is transformed into a rich red-brown pigment.

**CARBON BLACK** is a name which has been given in this country to a fine lamp black; in America the black sold under this name is made from the natural gas which is found in large quantities in and near Pittsburg. The black is made in several qualities; it contains, according to analyses made by the author, 3 to 5 per cent. of water and occluded gases and 95 to 97 per cent. of carbon. They are, therefore, some of the purest blacks known. Carbon blacks are largely used in making printing and lithographic inks of all kinds, in painting and for all other purposes where a fine black pigment is required. These blacks are also known as *Gas Blacks*.

**CARBONATE OF LEAD**, $PbCO_3$, occurs naturally as the mineral cerussite, containing 16·5 per cent. of carbonic acid gas and 83·5 per cent. of oxide of lead. It is found at Pentre Glaze in Cornwall, East Tamar Mine in Devonshire, in Derbyshire, at Leadhills and other localities. It dissolves in dilute nitric acid with effervescence. White lead is a basic carbonate of lead. The normal carbonate of lead has not been made artificially, but basic carbonates are readily obtained by precipitating solutions of lead salts with alkaline carbonates or with carbonic acid gas.

**CARBONATE OF POTASH,** $K_2CO_3$, is the principal constituent of the ashes of plants. It is usually prepared by burning the twigs and wood of trees, lixiviating the ashes thus obtained with water, filtering or clarifying the solution, and evaporating the liquor down in pots, from which fact the solid matter which is obtained has been named *potash* or *potashes*. If the crude potashes thus obtained be further refined, by treatment with a small quantity of water and a second evaporation of the solution, a purer variety known as *pearlash* is obtained.

Potashes, as a rule, are not very pure, containing variable quantities of potassium hydroxide, sulphate and chloride, sodium carbonate and hydroxide, silica and alumina. The following are a few analyses of commercial potashes of various origin :—

| | Variety. | | | | |
|---|---|---|---|---|---|
| | Montreal. | Pearlash. | French. | Beetroot. | Leblanc. |
| Potassium carbonate . . | 43·87 | 77·50 | 38·63 | 92·68 | 92·19 |
| Potassium hydroxide . . | 36·50 | — | — | — | — |
| Potassium sulphate . . | 10·40 | 11·65 | 0·43 | 3·81 | 3·94 |
| Potassium chloride . . | 2·43 | 2·65 | 2·45 | 2·92 | 1·49 |
| Sodium carbonate . . . | — | 2·86 | 3·98 | 3·98 | 1·43 |
| Sodium hydroxide . . . | 2·02 | — | 4·17 | — | — |
| Soluble silica, etc. . . . | 4·75 | 5·77 | 9·20 | 0·56 | 1·08 |

A good deal of potash is now made by the Leblanc process from the potassium chloride found at Stassfurt in Germany: this is much purer in quality than the potash obtained from wood. Potash is used for a great variety of purposes; in the manufacture of caustic potash, as also of various potassium compounds, such as potassium bichromate, potassium ferrocyanide, etc.; in the manufacture of glass, pottery and other articles. The method of analysing potash will be described under alkalimetry when dealing with caustic soda. (See *Caustic Soda.*) Potash is an easily soluble body, its solution possessing strong alkaline properties and a sharp taste. It is soluble in acids with effervescence, due to the evolution of carbonic acid gas.

**CARBONATE OF SODA**, $Na_2CO_3$, is a most valuable chemical product, and its manufacture is one of the most important branches (the alkali manufacture) of the chemical industries, giving employment to thousands of men. It is found to a limited extent in nature in the exuviations of the soil of Eastern and other hot countries. It is found in the ashes of sea weeds, and at one time these ashes, under the name of *Barilla Ash*, were made on a large scale and used for various purposes. Carbonate of soda or *soda*, as it is shortly called, is now obtained exclusively from the chloride, common salt, by one or other of two processes.

The oldest process of soda making is that known as the **Leblanc process**; in this the salt is first heated with sulphuric acid, whereby sulphate of soda is formed and hydrochloric acid gas evolved; this gas is condensed by passing it through stone towers filled with bricks down which water trickles. The water dissolves the acid gas and forms a strong acid solution, generally known as *spirits of salt*. The sulphate of soda is next heated in a furnace with coal and limestone, whereby it is converted into carbonate of soda, while at the same time sulphide of lime is also formed. The crude alkali so made is known as *black ash* and is sold to a small extent.

The crude black ash is next lixiviated with water which dissolves out the carbonate of soda (and any other alkaline salts which may be present), leaving the lime in an insoluble form; the solution is evaporated down and treated in various ways to obtain the alkali of commerce.

The second process, which is more modern, is that known as the **ammonia-soda process.** In this brine is mixed with ammonia and a current of carbonic acid gas is passed through; bicarbonate of soda is thrown down as a precipitate, while ammonium chloride remains in solution. The bicarbonate of soda is collected and used for preparing the commercial forms of soda.

Carbonate of soda, or soda, is sold commercially in several forms.

(1) **Soda Ash.**—This is the commonest form, consisting of a dry powder. It exists in various degrees of purity; the impurities present being caustic soda, sodium chloride, sodium sulphate, small quantities of insoluble matter, etc. The quality of the soda ash is measured in commerce by the amount of sodium oxide, $Na_2O$, which may be present in the form of carbonate or caustic; thus there is 48 per cent., 52 per cent., 54 per cent., and 58 per cent. ash; the last is nearly pure. The price is usually quoted at so much per unit per cwt.; the unit being each per cent. of oxide present in the ash.

(2) **Refined Alkali.**—This is nearly pure carbonate of soda, usually containing 58 per cent. of oxide of sodium.

(3) **Soda Crystals.**—This is the commonest crystalline form, and occurs in large transparent crystals with ten molecules of water of crystallisation and, therefore, having the formula $Na_2CO_3, 10H_2O$. Soda crystals generally contain small quantities of impurities, sodium chloride, sodium sulphate, etc. This is the form known as washing soda among laundresses and *sal soda* in America.

(4) **Crystal Carbonate or Crystal Soda** is the monohydrated crystal form containing one molecule of water of crystallisation and having the formula, $Na_2CO_3$, $H_2O$. This variety is usually very pure and fairly free from impurities.

(5) **Sesquicarbonate of Soda.**—This is a mixture of the carbonate and bicarbonate in equal molecular proportions and has the formula, $Na_2CO_3$, $NaHCO_3$. It is usually very pure, but is little used.

(6) **Bicarbonate of Soda,** $NaHCO_3$.—This is sold in two forms; as a powder, when it is commonly known as *carbonate of soda*, and is the form usually employed in medicine, cooking, etc., or as crystals. Bicarbonate of soda is usually fairly pure.

The following analyses of the various qualities of commercial soda will show the degree of impurity usually found present:—

### ANALYSIS OF SODA ASH.

| | 48 per Cent. Ash. | 58 per Cent Ash. |
|---|---|---|
| Sodium carbonate, $Na_2CO_3$ . . | 60·64 | 98·72 |
| Sodium sulphate, $Na_2SO_4$ . . . | 4·35 | 0·20 |
| Sodium hydroxide, NaOH . . | 1·29 | — |
| Sodium chloride, NaCl . . . | 28·34 | 0·54 |
| Calcium carbonate, $CaCO_3$ . . | traces | 0·13 |
| Magnesium carbonate, $MgCO_3$ . . | — | 0·04 |
| Iron oxide, $Fe_2O_3$, and alumina, $Al_2O_3$ | traces | 0·05 |
| Silica, $SiO_2$ . . . . . . | 1·12 | 0·09 |
| Water, $H_2O$ . . . . . . | 4·36 | 0·26 |

### ANALYSIS OF SODA CRYSTALS.

| | Per Cent. |
|---|---|
| Sodium carbonate . . . . . . | 34·22 |
| Sodium hydroxide . . . . . . | 0·12 |
| Sodium sulphate . . . . . . | 2·54 |
| Sodium chloride . . . . . . | 0·27 |
| Water . . . . . . . . . | 62·84 |
| Insoluble matter . . . . . . | 0·03 |

rom this analysis it will be seen that soda crystals contain ıore than half their weight of water.

ANALYSIS OF CRYSTAL CARBONATE.

| | Per Cent. |
|---|---|
| Sodium carbonate | 81·92 |
| Sodium sulphate | 0·18 |
| Sodium chloride | 0·24 |
| Water | 17·66 |

; will be seen that crystal carbonate not only contains much ss water than soda crystals, but is also much purer.

ANALYSIS OF AMMONIA-SODA ALKALI.

| | Per Cent. |
|---|---|
| Sodium carbonate | 98·72 |
| Sodium chloride | 0·54 |
| Sodium sulphate | 0·20 |
| Magnesium carbonate | 0·04 |
| Calcium carbonate | 0·13 |
| Ferric oxide | 0·01 |
| Alumina | 0·01 |
| Silica | 0·09 |
| Water | 0·32 |

This is fairly typical of the composition of 58 per cent. nmonia alkali. Although there is a goodly variety of impurities, yet they do not, on the whole, amount to much.

Sodium carbonate is readily soluble in water, but its soluility varies greatly with the temperature. At 0° C. 100 arts of water will dissolve 6·97 parts of the anhydrous salt, 21·33 parts of the crystals; at 10° C. 12·06 and 40·94 parts spectively are dissolved; at 15° C. 16·2 and 63·2 parts spectively; at 20° C. 21·71 and 92·82 parts respectively; hile at 38° C. the maximum solubility is reached, and 51·67 arts of the anhydrous and 1142·17 parts of the hydrated salt re dissolved by 100 parts of water.

The following tables give the specific gravity of solutions of carbonate of soda at 15° C. (60° F.) and at 30° C. (86° F.):—

| At 15° C. (60° F.). | | | | At 30° C. (86° F.). | | | |
|---|---|---|---|---|---|---|---|
| Specific Gravity. | Degrees Twaddell. | Per Cent. by Weight. | | Specific Gravity. | Degrees Twaddell. | Per Cent. by Weight. | |
| | | $Na_2O$. | $Na_2CO_3$. | | | $Na_2O$. | $Na_2CO_3$. |
| 1·005 | 1 | 0·28 | 0.47 | 1·155 | 31 | 8·71 | 14·89 |
| 1·010 | 2 | 0·56 | 0·95 | 1·160 | 32 | 8·96 | 15·32 |
| 1·015 | 3 | 0·84 | 1·42 | 1·165 | 33 | 9·21 | 15·74 |
| 1·020 | 4 | 1·11 | 1·90 | 1·170 | 34 | 9·46 | 16·18 |
| 1·025 | 5 | 1·39 | 2·38 | 1·175 | 35 | 9·71 | 16·60 |
| 1·030 | 6 | 1·67 | 2·85 | 1·180 | 36 | 9·96 | 17·04 |
| 1·035 | 7 | 1·95 | 3·33 | 1·185 | 37 | 10·21 | 17·46 |
| 1·040 | 8 | 2·22 | 3·80 | 1·190 | 38 | 10·46 | 17·89 |
| 1·045 | 9 | 2·50 | 4·28 | 1·195 | 39 | 10·71 | 18·32 |
| 1·050 | 10 | 2·78 | 4·76 | 1·200 | 40 | 10·97 | 18·75 |
| 1·055 | 11 | 3·06 | 5·22 | 1·205 | 41 | 11·22 | 19·18 |
| 1·060 | 12 | 3·34 | 5·71 | 1·210 | 42 | 11·47 | 19·61 |
| 1·065 | 13 | 3·61 | 6·17 | 1·215 | 43 | 11·72 | 20·04 |
| 1·070 | 14 | 3·88 | 6·64 | 1·220 | 44 | 11·97 | 20·47 |
| 1·075 | 15 | 4·16 | 7·10 | 1·225 | 45 | 12·23 | 20·90 |
| 1·080 | 16 | 4·42 | 7·57 | 1·230 | 46 | 12·48 | 21·33 |
| 1·085 | 17 | 4·70 | 8·04 | 1·235 | 47 | 12·73 | 21·77 |
| 1·090 | 18 | 4·97 | 8·51 | 1·240 | 48 | 12·98 | 22·20 |
| 1·095 | 19 | 5·24 | 8·97 | 1·245 | 49 | 13·24 | 22·63 |
| 1·100 | 20 | 5·52 | 9·43 | 1·250 | 50 | 13·49 | 23·07 |
| 1·105 | 21 | 5·79 | 9·90 | 1·255 | 51 | 13·74 | 23·50 |
| 1·110 | 22 | 6·06 | 10·37 | 1·260 | 52 | 14·00 | 23·93 |
| 1·115 | 23 | 6·33 | 10·83 | 1·265 | 53 | 14·24 | 24·35 |
| 1·120 | 24 | 6·61 | 11·30 | 1·270 | 54 | 14·49 | 24·77 |
| 1·125 | 25 | 6·88 | 11·76 | 1·275 | 55 | 14·73 | 25·19 |
| 1·130 | 26 | 7·15 | 12·23 | 1·280 | 56 | 14·98 | 25·61 |
| 1·135 | 27 | 7·42 | 12·70 | 1·285 | 57 | 15·22 | 26·03 |
| 1·140 | 28 | 7·70 | 13·16 | 1·290 | 58 | 15·47 | 26·45 |
| 1·145 | 29 | 7·97 | 13·63 | 1·295 | 59 | 15·72 | 26·87 |
| 1·150 | 30 | 8·46 | 14·4 | 1·300 | 60 | 15·96 | 27·29 |

Solutions of sodium carbonate have an alkaline reaction and taste. When soda crystals are heated they melt in their water of crystallisation, a property which is sometimes taken advantage of. The crystals effloresce in dry air. Sodium carbonate is a stable salt, and may be kept for any length of time without any change.

Soda is used in a very great variety of trades: in bleaching and washing all kinds of textile fabrics, in dyeing, in colour making, in glass making, etc.

The method of testing soda will be described under *Caustic Soda*.

**CARBONIC ACID.**—This acid is only known in the form of its anhydride, carbon dioxide gas, $CO_2$, which is familiarly known as carbonic acid. True carbonic acid is formed by the union of this gas with water, and has the formula $H_2CO_3$. Carbonic acid unites with metallic oxides to form a number of very important compounds known as *carbonates*, some of which are found occurring in large quantities in nature, as, for instance, calcium carbonate (in the various forms of chalk, limestone, marble, etc.), and magnesium carbonate (as the mineral magnesite). Sodium carbonate is found in some of the American lake deposits. From some carbonates—those of lime and magnesia—carbonic acid may be obtained by heating; from other carbonates by the action of acids. Carbonic acid is also produced during the combustion of carbon or any carbonaceous matter. It is a gaseous body, which, however, under pressure and cold, can be converted into a liquid, or even into a solid. Liquid carbonic acid is an article of commerce. The gas is rather heavier than air, its specific gravity being 1·529, air being 1·000. It is soluble in water, which, at the ordinary pressure and temperature, will absorb its own volume of the gas, but by increasing the pressure the quantity of gas dissolved is materially increased. Aerated waters are made by forcing carbonic acid gas at a high pressure into them and immediately bottling. On opening the bottle the pressure is reduced and the excess of gas escapes with effervescence. When a current of carbonic acid gas is passed through solutions of alkaline oxides, etc., it is absorbed, and the corresponding carbonate is formed.

**CARMINE** is a handsome red lake pigment prepared from cochineal. It has a bright crimson colour, is a powerful staining pigment, works well with either oil or water, but is fugitive when exposed to light and air. Carmine has an exceedingly complex composition, as is indicated by the following analysis by Lafar (*Journal für praktische Chemie*, 1890, No. 3):—

| | Per Cent. |
|---|---|
| Water | 15·50 |
| Ash | 6·87 |
| Nitrogenous matter | 23·26 |
| Colouring matter | 54·37 |
| The ash contained:— | |
| Copper oxide, CuO | 0·35 |
| Stannic oxide, $SnO_2$ | 0·14 |
| Alumina, $Al_2O_3$ | 40·48 |
| Ferric oxide, $Fe_2O_3$ | trace |
| Calcium oxide, CaO | 44·20 |
| Magnesia, MgO | 0·61 |
| Sodium oxide, $Na_2O$ | 5·40 |
| Potassium oxide, $K_2O$ | 3·20 |
| Phosphoric acid, $P_2O_5$ | 2·71 |
| Silica, $SiO_2$ | 0·60 |
| Carbonic acid, $CO_2$ | 2·31 |

Carmine is completely soluble in ammonia, and the presence of any matter which is insoluble in ammonia in a sample of carmine is an indication of the presence of adulterants. This is the best test for the purity of a sample of carmine. It is insoluble in water and alcohol and most other solvents. Caustic soda and potash dissolve it to form rich red solutions. From these the carmine is precipitated by exposure to the air or by aiding some weak acid, like acetic or tartaric. Solutions of some metals (iron, lead, copper) materially alter the colour of carmine. When carmine is burnt it leaves a greyish-white ash behind.

**CARMINE LAKE** is an alumina lake of a rich red colour prepared from the cochineal liquors which are left behind in making carmine. It has a fine colour, but is not so brilliant nor so strong in colouring power as carmine. It does not completely dissolve in ammonia, but it will do so in caustic soda or caustic potash. Strong acids will also dissolve it. It is used to a small extent in artistic painting, but it is rather a fugitive colour. It works well with either oil or water.

**CARNAUBA WAX.**—This wax is also known as *Brazil Wax.* It is obtained from the leaves of the tree, *Copernicia cerifera*, which is a native of Brazil. The leaves of this tree are found covered with a kind of wax. They are collected and placed in layers in the sun to dry. As they dry the wax shrinks and peels off. It is collected, melted, and sent into commerce. It makes its appearance in vitreous-looking lumps of a yellow or greenish-yellow colour. It is hard and brittle, has a specific gravity of 0·99, and melts at from 84° to 97° C. (183° to 206° F.). It has, according to the researches of Sturcke (*Annalen der Chemie*, ccxxiii., p. 283), a most complex composition, containing (1) a hydrocarbon having a melting point of 59° C.; (2) cerotyl alcohol, $C_{26}H_{53}CH_2OH$, which has a melting point of 76° C.; (3) myricyl alcohol, $C_{29}H_{59}CH_2OH$, which melts at 85° C.; (4) an alcohol having the formula $C_{23}H_{46}(CH_2OH)$, and a melting point of 103·5° C.; (5) an acid having the formula, $C_{23}H_{47}COOH$, and melting point of 72·5° C.; (6) cerotic acid, $C_{26}H_{53}COOH$, melting at 78° C.; and (7) an acid having the formula, $C_{19}H_{38}CH_2OHCOOH$

The principal constituents are myricyl alcohol, which is present to the extent of 45 per cent. in the wax ; cerotic acid, which is present to the extent of about 35 to 40 per cent. in the wax. The other constituents are present in but small quantities. When carnauba wax is treated with boiling alcohol 29 per cent., consisting of myricyl alcohol and some ether, is dissolved. In addition to being present in the free condition myricyl alcohol is also present in the form of an ether. There is very little free acid in carnauba wax, nearly all the acids being present in combination with the alcohols as ethers. Carnabau wax when boiled with an alcoholic solution of caustic potash undergoes saponification, requiring 7·9 per cent. of KOH, showing that its ethereal constituents have a high molecular weight. It combines with bromine, of which it absorbs 33·5 per cent. of its weight. Carnauba wax is employed in candle making, being added to wax candles to harden them. It is sometimes added to beeswax to raise the melting point.

**CASSEL EARTH** is the name given to a brown pigment of an earthy character found near Cassel in Germany. In composition it resembles Cappagh brown, but it is doubtful whether much of what is now sold as Cassel earth has ever come from Cassel.

**CAUSTIC POTASH** is the commercial name of potassium hydroxide, KOH. It is manufactured on the large scale by treating solutions of the carbonate with slaked lime, separating out the precipitated carbonate of lime and evaporating down until solidification occurs. When pure caustic potash is a white amorphous solid, and very hygroscopic, absorbing water readily from the atmosphere. It also readily absorbs carbonic acid, passing into the carbonate, and even into the bicarbonate.

Hence it is not advisable to expose solutions of caustic potash too much to the air. It possesses strongly caustic properties and a sharp taste. It readily saponifies fats and converts them into soaps, its action in this respect being stronger than that of caustic soda. It is a powerful base uniting with the strongest acids and forming the potassium salts, nearly all of which are soluble in water, and are of great importance in the arts. Caustic potash is readily soluble in water. The following table gives the strength of solutions of various gravities at 60° F., and is due to Dalton :—

### TABLE OF STRENGTH OF CAUSTIC POTASH SOLUTIONS AT 60° F.

| Specific Gravity. | Degrees Twaddell. | Per Cent. KOH. | Pounds KOH per Gallon. |
|---|---|---|---|
| 1·060 | 12 | 5·59 | 0·59 |
| 1·110 | 22 | 11·31 | 1·25 |
| 1·150 | 30 | 15·48 | 1·77 |
| 1·190 | 38 | 19·29 | 2·21 |
| 1·230 | 46 | 23·22 | 2·84 |
| 1·280 | 56 | 27·87 | 3·56 |
| 1·330 | 66 | 31·32 | 4·16 |
| 1·360 | 72 | 35·01 | 4·76 |
| 1·390 | 78 | 38·59 | 5·36 |
| 1·420 | 84 | 40·97 | 5·81 |
| 1·440 | 88 | 43·83 | 6·31 |
| 1·470 | 94 | 47·16 | 6·93 |
| 1·520 | 104 | 51·09 | 7·76 |
| 1·600 | 112 | 55·62 | 8·89 |
| 1·680 | 136 | 60·98 | 10·24 |
| 1·780 | 156 | 67·65 | 12·04 |
| 1·880 | 176 | 75·74 | 14·23 |
| 2·000 | 200 | 86·22 | 17·24 |

Commercial caustic potash is made in various qualities, three standard grades being recognised. The best quality ordinarily contains from 80 to 85 per cent. of actual potassium hydroxide ; the next quality is of 75 to 80 per cent.

strength; while the lowest quality contains from 70 to 75 per cent. strength. Of late a high strength caustic potash is being made by an electrical process at not too high a cost, which ought to become largely used in place of the low grade caustics. The following analyses of two samples of commercial caustic potash will show their average composition:—

| | Per Cent. No. 1. | Per Cent. No. 2. |
|---|---|---|
| Potassium hydroxide, KOH . . | 77·64 | 75·64 |
| Potassium carbonate, $K_2CO_3$ . . | 4·62 | 2·554 |
| Potassium sulphate, $K_2SO_4$ . . | 0·38 | 0·21 |
| Potassium chloride, KCl . . | 2·29 | 0·93 |
| Potassium nitrite, $KNO_2$ . . | 0·87 | — |
| Sodium hydroxide, NaOH . . | 4·67 | 2·59 |
| Soluble silica and alumina . . | 0·30 | 0·20 |
| Insoluble matter . . . . | 0·02 | 0·22 |
| Water . . . . . . . | 8·84 | 17·80 |

As will be seen, the impurities in commercial caustic potash are rather high, much more so than is the case with commercial caustic sodas. It is difficult to obtain commercial potash free from soda, the presence of which has sometimes a deleterious influence on the use of the potash compound.

The value of caustic potash can be ascertained by the same alkalimetric tests as are applied to soda, and will be found described under *Caustic Soda*. The quantities of sulphate, chloride, alumina and carbonate can be obtained by the usual methods for those constituents. It is rather difficult to estimate the amount of soda present; the best method will be to determine the amount of potassium present by means of platinum chloride, and to calculate the soda by the difference between the sulphuric acid required for the potassium so found and that used for the total alkalinity of the sample.

**CAUSTIC SODA** is the commercial name of sodium hydroxide, or sodium hydrate as it used to be formerly known to chemists. The body can be produced by the action of sodium on water ; commercially it is always made by treating solutions of sodium carbonate with quicklime and evaporating the solution so obtained to dryness. Its chemical formula is $NaOH$. Caustic soda is a white, hard, solid, melting at a little below a red heat, and is somewhat volatile at higher temperatures. It is very diliquescent, and is easily soluble in water, 1 part dissolving in 0·47 part of water. Great heat is given off during solution in water, the greatest amount being obtained when 40 parts of caustic soda are dissolved in 360 parts of water, these proportions corresponding to the ratio $NaOH, 20H_2O$. It is easily soluble in alcohol. The specific gravities of solutions of caustic soda of varying strengths will be found below. A solution containing 36 per cent. of $NaOH$ boils at 130° C. (266° F.) ; with 70 per cent. the boiling point is 180° C. (356° F.) ; with 78 per cent. the boiling point is 243° C. (469° F.) ; while a solution which contains 82 per cent. $NaOH$ has a boiling point of 260° C. (500° F.). Caustic soda possesses very strongly alkaline and caustic properties, and consequently it and its solutions require handling with care. It acts powerfully on the skin and all animal substances, corroding and dissolving them ; with such bodies it should not be brought into contact. Caustic soda when exposed to the air absorbs water and carbonic acid, so that it is important to keep solid caustic soda from exposure to the air as much as possible.

Commercial caustic soda is sold in several grades or qualities, the following being the chief : 60 per cent. cream, 60 per cent. white, 70 per cent., 74 per cent., and 77 per cent., the last being almost chemically pure (see analyses below). The percentages here quoted refer to the total proportion of oxide of sodium, $Na_2O$, in the caustic without distinction as to whether that is present in the form of carbonate or hydroxide. The lower grades of commercial caustic are far from pure. The following table shows the composition of the various grades of commercial caustic sodas:—

| | Cream, 60 per Cent. | White, 60 per Cent. | 70 per Cent. | 74 per Cent. | 77 per Cent. |
|---|---|---|---|---|---|
| Sodium hydroxide . . | 75·0 | 73·0 | 84·0 | 96·0 | 99·34 |
| Sodium carbonate . . | 3·1 | 1·5 | 4·2 | 0·2 | — |
| Sodium chloride . . | 6·8 | 19·0 | 6·0 | 1·3 | 0·21 |
| Sodium sulphate . . | 1·5 | 5·5 | 5·1 | 1·5 | 0·10 |
| Sodium silicate . . . | 2·1 | 0·3 | 0·3 | 0·1 | 0·05 |
| Sodium aluminate . . | 0·8 | trace | trace | 3·2 | 0·30 |
| Sodium sulphite . . . | 1·5 | — | — | — | — |
| Insoluble . . . . . | 0·2 | — | — | — | — |
| Water . . . . . . . | 9·0 | — | — | — | — |

These analyses may be taken as fairly representative; others will be found in *The Chemical Trade Journal*, 1888, p. 83.

The lower grades are sold in drums of varying size, which are filled with the caustic when the latter has been melted by heat. The higher grades are also sold in a powder form, which is the most convenient for small users.

Caustic soda is largely employed in soap making, in bleaching textile fibres (especially the vegetable fibres), in glass making, in colour making, in paper making and in other industries. In most cases it is employed in the form of a solution, in which form it is a commercial article, having usually a specific gravity of 1·35 (70° Tw.), and containing about 30 per cent. of actual hydroxide. It can also be bought having a gravity of 100° Tw. (specific gravity 1·5). This contains about 50 per cent. of actual caustic.

The following table gives the strength in actual caustic f solutions of sodium hydroxide of varying gravities:—

### SPECIFIC GRAVITY OF CAUSTIC SODA SOLUTIONS AT 15° C. (60° F.).

| Degrees Twaddell. | Specific Gravity. | Per Cent. by Weight of | | Pounds of actual NaOH contained in one Gallon of Lye made Commercial Caustic of | | |
|---|---|---|---|---|---|---|
| | | $Na_2O$. | NaOH. | 77 per Cent. | 74 per Cent. | 70 per Cent. |
| 1 | 1·005 | 0·368 | 0·474 | 0·048 | 0·046 | 0·043 |
| 2 | 1·010 | 0·742 | 0·957 | 0·097 | 0·092 | 0·087 |
| 3 | 1·015 | 1·114 | 1·436 | 0·146 | 0·131 | 0·129 |
| 4 | 1·020 | 1·480 | 1·909 | 0·194 | 0·185 | 0·180 |
| 5 | 1·025 | 1·834 | 2·365 | 0·243 | 0·231 | 0·219 |
| 6 | 1·030 | 2·194 | 2·830 | 0·291 | 0·278 | 0·262 |
| 7 | 1·035 | 2 521 | 3·252 | 0·335 | 0·320 | 0·303 |
| 8 | 1·040 | 2·904 | 3·746 | 0·389 | 0·371 | 0·350 |
| 9 | 1·045 | 3·244 | 4·184 | 0·438 | 0·417 | 0·393 |
| 10 | 1·050 | 3·590 | 4·631 | 0·486 | 0·461 | 0·438 |
| 11 | 1·055 | 3·943 | 5·086 | 0·536 | 0·510 | 0·483 |
| 12 | 1·060 | 4·292 | 5·536 | 0·586 | 0·558 | 0·528 |
| 13 | 1·065 | 4·638 | 5·982 | 0·636 | 0·607 | 0·573 |
| 14 | 1·070 | 4·972 | 6·413 | 0·680 | 0·653 | 0·617 |
| 15 | 1·075 | 5·311 | 6·911 | 0·742 | 0·707 | 0·668 |
| 16 | 1·080 | 5·648 | 7·285 | 0·786 | 0·749 | 0·709 |
| 17 | 1·085 | 5·981 | 7·745 | 0·836 | 0·798 | 0·755 |
| 18 | 1·090 | 6·311 | 8·140 | 0·886 | 0·845 | 0·800 |
| 19 | 1·095 | 6·639 | 8·564 | 0·937 | 0·894 | 0·846 |
| 20 | 1·100 | 6·954 | 8·970 | 0·986 | 0·941 | 0·890 |
| 21 | 1·105 | 7·276 | 9·386 | 1·037 | 0·989 | 0·938 |
| 22 | 1·110 | 7·594 | 9·796 | 1·087 | 1·037 | 0·981 |
| 23 | 1·115 | 7·910 | 10·203 | 1·137 | 1·123 | 1·026 |
| 24 | 1·120 | 8·223 | 10·607 | 1·187 | 1·175 | 1·071 |
| 25 | 1·125 | 8·533 | 11·107 | 1·238 | 1·181 | 1·117 |
| 26 | 1·130 | 8·893 | 11·471 | 1·296 | 1·237 | 1·170 |
| 27 | 1·135 | 9·251 | 11·933 | 1·354 | 1·292 | 1·222 |
| 28 | 1·140 | 9·614 | 12·401 | 1·413 | 1·350 | 1·277 |
| 29 | 1·145 | 9·965 | 12·844 | 1·470 | 1·413 | 1·337 |
| 30 | 1·150 | 10·313 | 13·303 | 1·529 | 1·460 | 1·381 |
| 31 | 1·155 | 10·666 | 13·859 | 1·600 | 1·528 | 1·445 |
| 32 | 1·160 | 11·008 | 14·190 | 1·646 | 1·541 | 1·456 |
| 33 | 1·165 | 11·347 | 14·637 | 1·705 | 1·627 | 1·539 |
| 34 | 1·170 | 11·691 | 15·081 | 1·764 | 1·684 | 1·593 |
| 35 | 1·175 | 12·025 | 15·512 | 1·822 | 1·739 | 1·645 |

## SPECIFIC GRAVITY OF CAUSTIC SODA SOLUTIONS AT 15° C. (60° F.)—*continued.*

| Degrees Twaddell. | Specific Gravity. | Per Cent. by Weight of | | Pounds of actual NaOH contained in one Gallon of Lye made Commercial Caustic of | | |
|---|---|---|---|---|---|---|
| | | $Na_2O$. | NaOH. | 77 per Cent. | 74 per Cent. | 70 per Cent. |
| 36 | 1·180 | 12·356 | 16·139 | 1·904 | 1·817 | 1·719 |
| 37 | 1·185 | 12·692 | 16·372 | 1·942 | 1·853 | 1·753 |
| 38 | 1·190 | 13·016 | 16·794 | 1·998 | 1·887 | 1·804 |
| 39 | 1·195 | 13·339 | 17·203 | 2·055 | 1·962 | 1·856 |
| 40 | 1·200 | 13·660 | 17·629 | 2·122 | 2·026 | 1·916 |
| 41 | 1·205 | 14·058 | 18·133 | 2·185 | 2·085 | 1·973 |
| 42 | 1·210 | 14·438 | 18·618 | 2·252 | 2·147 | 2·033 |
| 43 | 1·215 | 14·823 | 19·121 | 2·323 | 2·221 | 2·097 |
| 44 | 1·220 | 15·124 | 19·613 | 2·392 | 2·280 | 2·161 |
| 45 | 1·225 | 15·502 | 19·997 | 2·444 | 2·338 | 2·206 |
| 46 | 1·230 | 15·959 | 20·586 | 2·562 | 2·417 | 2·285 |
| 47 | 1·235 | 16·299 | 20·996 | 2·593 | 2·475 | 2·341 |
| 48 | 1·240 | 16·692 | 21·532 | 2·669 | 2·548 | 2·410 |
| 49 | 1·245 | 17·060 | 22·008 | 2·739 | 2·615 | 2·474 |
| 50 | 1·250 | 17·424 | 22·476 | 2·809 | 2·681 | 2·536 |
| 51 | 1·255 | 17·800 | 22·962 | 2·881 | 2·750 | 2·602 |
| 52 | 1·260 | 18·166 | 23·433 | 2·952 | 2·818 | 2·666 |
| 53 | 1·265 | 18·529 | 23·901 | 3·020 | 2·886 | 2·730 |
| 54 | 1·270 | 18·897 | 24·376 | 3·095 | 2·955 | 2·795 |
| 55 | 1·275 | 19·255 | 24·858 | 3·171 | 3·027 | 2·863 |
| 56 | 1·280 | 19·609 | 25·295 | 3·237 | 3·090 | 2·932 |
| 57 | 1·285 | 19·961 | 25·750 | 3·308 | 3·158 | 2·988 |
| 58 | 1·290 | 20·318 | 26·210 | 3·381 | 3·227 | 3·053 |
| 59 | 1·295 | 20·665 | 26·658 | 3·452 | 3·364 | 3.117 |
| 60 | 1·300 | 21·156 | 27·110 | 3·524 | 3·394 | 3·182 |
| 61 | 1·305 | 21·405 | 27·611 | 3·603 | 3·439 | 3·253 |
| 62 | 1·310 | 21·785 | 28·105 | 3·682 | 3·514 | 3·264 |
| 63 | 1·315 | 22·168 | 28·595 | 3·760 | 3·593 | 3·395 |
| 64 | 1·320 | 22·556 | 29·161 | 3·849 | 3·674 | 3·475 |
| 65 | 1·325 | 22·926 | 29·574 | 3·919 | 3·742 | 3·539 |
| 66 | 1·330 | 23·310 | 30·058 | 3·997 | 3·816 | 3·610 |
| 67 | 1·335 | 23·670 | 30·535 | 4·072 | 3·891 | 3·681 |
| 68 | 1·340 | 24·046 | 31·018 | 4·156 | 3·967 | 3·754 |
| 69 | 1·345 | 24·410 | 31·490 | 4·232 | 4·042 | 3·824 |
| 70 | 1·350 | 24·765 | 31·948 | 4·312 | 4·116 | 3·894 |
| 71 | 1·355 | 25·152 | 32·446 | 4·396 | 4·196 | 3·970 |
| 72 | 1·360 | 25·526 | 32·930 | 4·478 | 4·274 | 4·043 |
| 73 | 1·365 | 25·901 | 33·415 | 4·561 | 4·354 | 4·109 |
| 74 | 1·370 | 26·285 | 33·905 | 4·645 | 4·434 | 4·194 |
| 75 | 1·375 | 26·650 | 34·382 | 4·728 | 4·513 | 4·269 |

## SPECIFIC GRAVITY OF CAUSTIC SODA SOLUTIONS AT 15° C. (60° F.)—*continued.*

| Degrees Twaddell. | Specific Gravity. | Per Cent. by Weight of | | Pounds of actual NaOH contained in one Gallon of Lye made Commercial Caustic of | | |
|---|---|---|---|---|---|---|
| | | $Na_2O$. | NaOH. | 77 per Cent. | 74 per Cent. | 70 per Cent. |
| 76 | 1·380 | 27·021 | 34·855 | 4·810 | 4·592 | 4·344 |
| 77 | 1·385 | 27·385 | 35·328 | 4·893 | 4·670 | 4·418 |
| 78 | 1·390 | 27·745 | 35·795 | 4·975 | 4·749 | 4·493 |
| 79 | 1·395 | 28·110 | 36·258 | 5·058 | 4·828 | 4·567 |
| 80 | 1·400 | 28·465 | 36·720 | 5·141 | 4·907 | 4·642 |
| 81 | 1·405 | 28·836 | 37·203 | 5·227 | 4·989 | 4·702 |
| 82 | 1·410 | 29·203 | 37·674 | 5·312 | 5·071 | 4·797 |
| 83 | 1·415 | 29·570 | 38·146 | 5·397 | 5·153 | 4·873 |
| 84 | 1·420 | 29·930 | 38·610 | 5·482 | 5·233 | 4·950 |
| 85 | 1·425 | 30·285 | 39·071 | 5·567 | 5·314 | 5·027 |
| 86 | 1·430 | 30·645 | 39·530 | 5·653 | 5·396 | 5·104 |
| 87 | 1·435 | 30·995 | 39·986 | 5·738 | 5·467 | 5·181 |
| 88 | 1·440 | 31·349 | 40·435 | 5·823 | 5·558 | 5·258 |
| 89 | 1·445 | 31·700 | 40·882 | 5·908 | 5·640 | 5·335 |
| 90 | 1·450 | 32·043 | 41·335 | 5·923 | 5·721 | 5·412 |
| 91 | 1·455 | 32·460 | 41·875 | 6·093 | 5·816 | 5·502 |
| 92 | 1·460 | 32·870 | 42·400 | 6·191 | 5·909 | 5·630 |
| 93 | 1·465 | 33·283 | 42·935 | 6·290 | 6·004 | 5·679 |
| 94 | 1·470 | 33·695 | 43·467 | 6·389 | 6·099 | 5·769 |
| 95 | 1·475 | 34·092 | 43·980 | 6·487 | 6·193 | 5·856 |
| 96 | 1·480 | 34·500 | 44·505 | 6·586 | 6·287 | 5·948 |
| 97 | 1·485 | 34·899 | 45·013 | 6·685 | 6·381 | 6·035 |
| 98 | 1·490 | 35·245 | 45·530 | 6·784 | 6·476 | 6·126 |
| 99 | 1·495 | 35·691 | 46·041 | 6·884 | 6·571 | 6·216 |
| 100 | 1·500 | 36·081 | 46·545 | 6·982 | 6·665 | 6·303 |

The figures in the last three columns have been calculated on the assumption that in the case of the 74 and 70 per cent. caustics the impurities in them have an influence on the specific gravity of the solution equal to that of an equal weight of hydroxide. The figures in the column for 77 per cent. caustic are fairly accurate.

Sodium hydroxide is a powerful base; it unites with all acids forming the sodium salts, nearly all of which are soluble in water, varying a little in their degree of solubility. Chlorine, bromine and iodine react with a solution of sodium hydroxide, forming chlorates, bromates and iodates, especially if hot solutions are employed. Carbonic acid passed through the solution throws down sodium bicarbonate, $NaHCO_3$. The solution precipitates many metallic hydroxides from solutions of the salts; for example, iron, copper, lead, aluminium, tin, chromium, etc. Some of these hydroxides, *viz.*, those of aluminium, tin, lead and zinc are soluble in excess of the alkali.

Alkalimetry is the name given to the testing of the actual strengths or qualities of commercial potashes and sodas. It is in general done by volumetric processes, all of which depend upon the fact that when either the carbonates or the hydroxides of potassium and sodium are treated with sulphuric or hydrochloric acid they are neutralised and form neutral solutions of the sulphate or of the chloride of the metal as the case may be. Further, that in litmus, methyl orange or phenol-phthalein we have coloured bodies which are exceedingly sensitive to the action of acids or alkalies; methyl orange and litmus will turn red with the smallest excess of acid, while phenol-phthalein will show the slightest excess of either the potassium or sodium hydroxide. Given now a solution of one of the alkalies, on adding a little methyl orange, just sufficient to give it a yellow tint, and then adding a dilute solution of sulphuric acid, the slightest excess of the latter will turn the colour of the solution from yellow to red. If a solution of sulphuric acid of known strength were used and the amount measured, then the latter is a measure of the quantity of alkali present, for the union of the acid and the alkali take place in definite proportions according to the following equations:—

$$K_2CO_3 + H_2SO_4 = K_2SO_4 + CO_2 + H_2O$$
$$Na_2CO_3 + H_2SO_4 = Na_2SO_4 + CO_2 + H_2O$$
$$2NaOH + H_2SO_4 = Na_2SO_4 + H_2O$$
$$2KOH + H_2SO_4 = K_2SO_4 + H_2O$$

From these equations the following series of equivalents may be obtained: 49 parts of sulphuric acid, $H_2SO_4$, are equivalent to 40 parts of sodium hydroxide, NaOH, or to 56 parts of potassium hydroxide, KOH, or to 53 parts of sodium carbonate, $Na_2CO_3$, or to 69 parts of potassium carbonate, $K_2CO_3$.

In carrying out the principles of alkalimetry there is required a solution of sulphuric acid of known strength; this is called a *standard solution*, and is usually made to contain 49 grammes of actual $H_2SO_4$ in one litre or 1,000 c.c. As this solution contains the equivalent weight in grammes per litre of sulphuric acid it is called *normal standard solution*. In place of sulphuric acid, hydrochloric acid may be employed, in which case the normal standard solution will contain 36·5 grammes of HCl per litre. The methods are the same whether the soda or the potash compounds are being tested.

*Testing Soda Ash and Potashes.*—Weigh out 5 grammes of the sample, place in a beaker with water, and stir well until dissolved; then transfer to a graduated measuring flask holding 250 c.c., that is, a flask which on being filled to a mark on the neck, has the capacity stated. Then fill up the flask to the mark and shake well. By means of a pipette take out 25 c.c. of the solution and transfer to a beaker, add a little methyl orange solution, not too much, but just enough to give a definite yellow colour to the solution. Fill a burette with the standard solution of sulphuric acid; when ready turn on the tap or open the pinch cock of the burette, and drop the acid into the alkaline solution slowly, stirring it while doing so. The acid is dropped in until the colour of the solution turns pink, when the number of cubic centimetres of acid used are read off on the burette. The operation is known as *titrating.* It is advisable to repeat the test two or three times, and to take the mean of the results; that is, if there be not more than 0·1 c.c. of difference between them.

Sometimes litmus is employed as an indicator as to the end of the reaction between the acid and the alkali, in which case the change of colour is from blue to red. The results are, however, liable to come out too low, unless the test solution be kept boiling, owing to the fact that litmus is sensitive to carbonic acid, and that the small quantity of the latter which is liberated in the reaction remains in solution and affects the litmus. On this account methyl orange, which is not thus affected, is to be preferred.

The number of cubic centimetres of acid used, multiplied by 0·053 in the case of sodium carbonate, or by 0·069 when potashes are being tested, gives the quantity of either carbonate of sodium or of potassium in the 25 c.c. of solution taken. The percentage can then be easily calculated.

In the case of soda ashes it is customary to state the strength in terms of the amount of sodium oxide, $Na_2O$, they contain. In this case the cubic centimetres of standard acid used is multiplied by 0·031.

*Caustic Soda and Caustic Potash.*—The method of testing is identical with that employed for the carbonates. The necessary calculations are made by using the factors 0·04 for soda and 0·056 for potash, or if the amount of sodium oxide is required, as is usual in testing sodas, the factor is 0·031.

The question of the amount of carbonate of soda or potash, as the case may be, in commercial caustics is often a matter of importance, especially where these articles have to be employed in soap making. The carbonate in caustics may be tested for in the following manner: Weigh out 5 grammes of the sample, dissolve in 250 c.c. of water, and test for total alkali as before. Next, take 50 c.c. of the caustic solution and place in a 100 c.c. flask, add now a few cubic centimetres of a neutral solution of barium chloride, which will throw down a precipitate of barium carbonate by reaction with the alkaline carbonate present; make up the volume of the mixture to 100 c.c. The precipitate may be allowed to settle, and 50 c.c. of the clear liquor taken for titration; or it may be filtered, and 50 c.c. of the filtrate taken and titrated as before. This gives the alkali present as hydroxide or caustic. The quantity taken of the liquor is equal to 25 c.c. of the original solution. The difference in the quantity of acid used in the two tests shows the amount of carbonate in the sample.

The following details of some practical tests carried out in the manner described above will show how they work and the method of calculating.

*Sample of Soda Ash.*—Took 5 grammes and made up to 250 c.c.; took 25 c.c. of the solution for titration:—

*Standard Acid*:—

| | |
|---|---|
| Second reading . . . . . | 10·5 |
| First reading . . . . . | 3·0 |
| Acid used . . . . . | 7·5 |

$7·5 \times 0·031 = 0·1085$ gramme of sodium oxide present.
$0·5 : 0·1085 :: 100 : x$. $x = 46·5$ per cent. of sodium oxide.

This is a sample of 46·5 soda ash.

To calculate the quantity of sodium carbonate—

$7·5 \times 0·053 = 0·3975$ gramme of sodium carbonate.
$0·5 : 0·3975 :: 100 : x$. $x = 79·5$.

The sample, therefore, contains 79·5 per cent. of sodium carbonate.

*Sample of Potash.*—Took 5 grammes dissolved in 250 c.c. of water; took 25 c.c. for titration.

*Standard Acid :—*

| | |
|---|---|
| Second reading . . . . | 15·8 |
| First reading . . . . | 9·5 |
| Acid used . . . . . | 6·3 |

$6·3 \times 0·069 = 0·4347$ gramme of potassium carbonate.
$0·5 : 0·4347 :: 100 : x. \quad x = 79·5.$

This sample contains 79·5 per cent. of potassium carbonate.

*Sample of Caustic Soda.*—Took 5 grammes and dissolved in 250 c.c. of water.

Total alkali: took 35 c.c. and titrated with standard acid.

*Standard Acid :—*

| | |
|---|---|
| Second reading . . . . | 18·2 |
| First reading . . . . | 6·7 |
| Acid used . . . . . | 11·5 |

$11·5 \times 0·31 = 0·3565$ gramme of sodium oxide.
$0·5 : 0·3565 :: 100 : x. \quad x = 71·3.$

The total alkali is, therefore, 71·3 per cent.

*Soda as Carbonate.*—Took 50 c.c., added barium chloride made up to 100 c.c., filtered and took 50 c.c. of the filtrate = 25 c.c. of the original solution.

*Standard Acid :—*

| | |
|---|---|
| Second reading . . . . | 28·4 |
| First reading . . . . | 18·2 |
| Acid used . . . . . | 10·2 |

$10·2 \times 0·031 = 0·03162$ gramme of sodium oxide as hydroxide.
$0·5 : 0·3162 :: 100 : x. \quad x = 65·2.$

There is, therefore, 65·2 per cent. of alkali, as hydroxide or caustic, in this sample.

| | |
|---|---|
| Total alkali . . . . . | 71·3 |
| Alkali as caustic . . . . | 65·2 |
| Alkali as carbonate . . . | 6·1 |

The actual hydroxide can be calculated thus:—

Acid for alkali as caustic . . 10·2 c.c.
10·2 × 0·04 = 0·408.
0·5 : 0·408 : : 100 : $x$. $x = 81·6$.

There is, then, 61·6 per cent. of sodium hydroxide in the sample.

The amount of sodium carbonate is calculated thus:—

Acid for total alkali . . . 11·5
Acid for alkali as hydroxide . . 10·2
Acid for alkali as carbonate . . 1·3
1·3 × 0·053 = 0·0689.
0·5 : 0·0689 : : 100 : $x$. $x = 15·8$.

There is, therefore, 15·8 per cent. of sodium carbonate in this sample.

Caustic potashes are tested in the same way, using, however, different factors in calculating.

The following table of factors will be useful in making alkalimetrical tests:—

1 c.c. normal standard acid = 0·023 gramme sodium.
1 ,, ,, = 0·031 ,, sodium oxide.
1 ,, ,, = 0·04 ,, sodium hydroxide.
1 ,, ,, = 0·053 ,, sodium carbonate.
1 ,, ,, = 0·039 ,, potassium.
1 ,, ,, = 0·047 ,, potassium oxide.
1 ,, ,, = 0·056 ,, potassium hydroxide.
1 ,, ,, = 0·069 ,, potassium carbonate.

**CERESIN.**—This material is prepared from *Ozokerit* (which see) by a process of treating it with strong sulphuric acid, washing and filtering through charcoal. It makes its appearance in commerce as a yellow, waxy-looking material, having a granular structure and closely resembling beeswax, for which it is often substituted. It is employed for a variety of purposes where a wax is required. It melts at from 120° F. to 140° F., is quite insoluble in water and alcohol, but soluble in ether, petroleum spirit and turpentine. It is unacted upon by acids or alkalies in the cold. In composition it consists chiefly of solid paraffins.

**CHARCOAL BLACKS** are products obtained by grinding charcoal: they are sometimes employed in making black paints, but more often in making moulds for casting metals, filtering, etc. They consist chiefly of carbon, but usually contain a small proportion of ash and some water.

**CHARLTON WHITE,** a name given to Orr's white. See *Orr's White.*

**CHINA CLAY.**—This very valuable material is found naturally in large quantities among the granite rocks of Cornwall and other localities in this and other countries, which are too numerous to mention. It is a hydrated silicate of alumina, having the composition :—

| | Per Cent. |
|---|---|
| Silica, $SiO_2$ | 47 |
| Alumina, $Al_2O_3$ | 40 |
| Water, $H_2O$ | 13 |

which corresponds with the formula $2SiO_2, Al_2O_3, 2H_2O$: but the composition varies somewhat from this average formula, as will be seen from the analyses which are given below, of china clays obtained from various localities.

Of the origin of china clay something will be said when dealing with clay. See *Clay.*

China clay is found in large deposits in the granite rocks, intermingled more or less with the mica and quartz of those rocks; from these substances it is separated by a process of levigation which will be found fully described in the author's

*Manual of Painters' Colours*, and also in Mr. David Cook's *Treatise on China Clay*.

China clay or kaolin, is a fine white amorphous powder, having slightly adhesive properties; when moist it adheres to the fingers. It is light, its specific gravity being 2·2, so that it is lighter than any other substance used as a white pigment. The best qualities have a soft, smooth feel, the common qualities are rather harsher, but few, if any, have a gritty feel. The best qualities have a pure white tint. A few grades have a yellowish tone, but the china clay makers are in the habit of correcting this by adding a little ultramarine. It is quite insoluble in dilute acids, alkalies and water. Boiling in strong sulphuric acid for some time gradually brings about its decomposition, resulting in the formation of alumina sulphate and the production of a gelatinous residue of silica. Hydrochloric acid has but little action; it is quite unaffected by heat, with the exception that at high temperature it passes into the anhydrous silicate of alumina.

ANALYSES OF CHINA CLAYS.

| Constituent. | Cornwall. | China. | Laurence Co., America. | French. | Dartmoor. | Cornwall. |
|---|---|---|---|---|---|---|
| Silica, $SiO_2$ . . . | 46·78 | 50·50 | 47·13 | 48·37 | 47·20 | 46·32 |
| Alumina, $Al_2O_3$ . | 39·60 | 33·76 | 36·76 | 34·95 | 38·80 | 39·72 |
| Water, $H_2O$ . . | 13·16 | 11·22 | 15·13 | 12·62 | 12·00 | 12·67 |
| Potash, $K_2O$ . . | 0·12 | 1·90 | — | 2·40 | 1·76 | 0·44 |
| Ferric oxide, $Fe_2O_3$ | 0·09 | 1·80 | trace | 1·26 | — | 0·27 |
| Lime, $CaO$ . . . | 0·07 | — | 0·04 | — | 0·24 | 0·36 |
| Magnesia, $MgO$ . | — | 0·80 | — | — | — | 0·36 |

China clay is largely employed in the manufacture of pottery, in making lake pigments, in the sizing and finishing of textile fabrics, as a filler for paper, etc.

In testing china clays it is important to pay attention to the purity of colour, which may be done by comparison with a standard sample—a small heap of the sample being placed beside a similar heap of the standard on a sheet of dead black surface paper in front of a window. Freedom from grit is important; this may be tested by placing a little in the mouth or by rubbing a little between two pieces of glass. The fineness of the clay is sometimes important; this may be tested by comparison with a standard sample by weighing 10 grammes, placing in a tall, cylindrical measuring glass of 500 c.c. capacity, shaking well up with water, filling the cylinder up to the mark with water, allowing the clay to settle, and noting the time it takes to settle down to a certain mark. The sample which takes the longest is finer in quality than the sample which takes the least time. It is rarely that an analysis of china clay is required, as the exact chemical composition is not often a matter of importance. China clay is rarely, if ever, adulterated; it is too cheap.

**CHINESE BLUE,** the name given to the best quality of *Prussian Blue* (which see), sold in small cubical pieces, notable for their bronze lustre and the coppery hue of their fractured surfaces: it is also sold in the form of powder. Chinese blue is easily soluble in oxalic acid.

**CHINESE LACQUER** is identical with Japan lacquer. See *Japanese Lacquer.*

**CHINESE GREEN.**—Chinese green or lokao is a pigment prepared from the juice of some Chinese species of buckthorn. The berries are pressed, the juice mixed with alum and dried. It makes its appearance in the form of bluish-green cakes, rather difficult to powder. It contains 27 to 47 per cent. of mineral matter, which consists chiefly of lime and alumina.

It is probable that Chinese green is a lake of the colouring principle of the berries united with alumina and lime. The colouring principle is a glucoside, which yields a glucose having the formula $C_6H_{12}O_6$, to which the name *lokaose* has been given. The glucoside itself has received the names *lokain* and *lokaonic acid*, and to it has been assigned the formula $C_{42}H_{48}O_{27}$. Besides the glucose there can also be obtained a peculiar acid named *lokanic acid*. The chemistry of Chinese green requires further investigation. It is but little used.

**CHINESE RED,** a name sometimes given to Derby red. See *Derby Red.*

**CHINESE WAX,** also known as *insect wax*. This wax is found on the bark and twigs of an evergreen tree growing in Western China, the *Legistrum lucidum*. It is deposited by an insect, the *coccus pela*. The wax is scraped off into boiling water, when it melts and rises to the surface, from which it is skimmed and then poured into moulds. It is a white, or greyish-white, fibrous and very lustrous wax. It melts at 82° C. (180 F.). It consists of the cerotate of ceryl, and has the formula $C_{26}H_{53}COOC_{27}H_{55}$. It is employed in candle making and as a glazing material. Its specific gravity at 15° C. (60° F.) is 0·970 ; at 100° C. (212° F.), 0·810 (compared with water at 15° C.). It is rather difficult to saponify, and requires 6·3 per cent. of KOH, potassium hydroxide, to do so. It is very slightly soluble in ether, but easily soluble in benzene, from which it crystallises on cooling.

**CHINESE WHITE,** the artists' name for zinc white. See *Zinc White.*

**CHROMATES** are a class of salts derived from the trioxide of chromium, $CrO_3$, or rather from the true chromic acid,

$H_2CrO_4$, which has not yet been prepared in the free condition. The chromates are very valuable substances, comprising many useful pigments, chrome yellow, Derby red, zinc chrome, etc., while the alkaline chromates are largely used in colour-making, dyeing, calico-printing, etc. They are characterised by the following properties: In colour they range from yellow to red. The alkaline chromates are soluble in water, so is the chromate of calcium: but other chromates are insoluble in water. They have a tendency to form three classes of chromates, acid, neutral or basic. Acid chromates, of which potassium bichromate is an example, tend to be of the type $R.RCrO_4CrO_3$, in which R represents an equivalent quantity of base. It will be seen that the acidity is due to the excess of the chromic anhydride. The heavy metals have a tendency to form basic chromates of the type $RCrO_4RO$. They are powerful oxidising agents, which is due to the fact that in the presence of oxidisable bodies they are easily reduced, the chromium passing from the acid to the basic condition; it is on this property that many of the industrial uses of chromates depend. Many of the chromates when boiled with an acid, especially if a little alcohol be present, are decomposed and reduced, the reaction being accompanied by a change of colour from yellow or red to green; this reaction is eminently characteristic of chromates. See *Bichromate of Potash*, *Chrome Yellow* and *Derby Red*.

**CHROME ALUM.**—This salt forms large violet-coloured octahedral crystals having the composition $K_2Cr_24SO_4, 24H_2O$, and containing 15·11 per cent. chrome oxide, $Cr_2O_3$, 9·41 per cent. potash, $K_2O$, 32·03 per cent. sulphur trioxide, $SO_3$, and 43·24 per cent. water. It is soluble in about 12 times its weight of cold water and 3 times its weight of hot water. It is used in lake making for the sake of the chrome it contains. The value of chrome alum is ascertained in the same way as testing ordinary alum for alumina; too large an excess of ammonia is not desirable, as the chromium hydroxide is slightly soluble, forming a violet-coloured liquid. By adding soda or ammonium carbonate to solutions of chrome alum a green precipitate of chromium oxide is obtained —carbonic acid being evolved. The green precipitate is used in the manufacture of lakes from natural dyewoods and the alizarine series of coal-tar dyes.

**CHROME ORANGE.**—An orange pigment which is essentially a mixture of the normal and basic chromates of lead (see *Chrome Yellow* and *Derby Red*). Commercial chrome orange varies in shade from a pale orange to a dark orange red; besides the chromates of lead there is often present sulphate of lead and sometimes barytes and whiting. When only sulphate of lead is present, the product is considered as a "pure" chrome orange. Tests for chrome orange will be found described under *Chrome Yellow*. The following are analyses of two samples of "pure" chrome oranges:—

| | "Pure" Orange Chrome. Per Cent. | "Pure" Deep Orange Chrome. Per Cent. |
|---|---|---|
| Water and volatile matter . | 3·26 | 1·27 |
| Lead chromate, $PbCrO_4$ . | 60·31 | 59·67 |
| Lead oxide and hydrate . | 35·47 | 39·47 |

**CHROME GREEN.**—This pigment is the oxide of the metal chromium, and is usually made by fusing together bichromate of potash and boracic acid. It is a bright green powder, insoluble in water and acids, and not acted on by alkalies nor by heat. It is the most permanent green known.

Chrome green should answer to the following tests: It should not impart a yellow colour to dilute hydrochloric acid when boiled with that substance, a yellow colouration might

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indicate the presence of chrome yellow or of potassium bichromate, which would be due to defective washing. When boiled with caustic soda, no apparent change should take place. The liquor should be divided into two portions; to one add acetic acid, when no yellow precipitate of chrome yellow should be obtained; to the other add hydrochloric acid and ferric chloride, when no blue precipitate indicating the presence of Brunswick green should be obtained. See *Guignet's Green*.

**CHROME RED.**—A name given to Derby red. See *Derby Red*.

**CHROME YELLOW.**—A very valuable pigment consisting essentially of the chromate of lead, $PbCrO_4$. The chrome yellows are made in a great variety of tints varying from a pale "primrose" yellow, through "lemon" and "medium" to a "deep" chrome yellow of a gold shade. Most chrome yellows, more especially the paler tints, contain lead sulphate, which acts as a toning colour and reduces the tint of the pigment; such pigments are considered as "pure" chromes from a commercial point of view. A common class of chrome yellows are made which contain barytes, gypsum or china clay as a tinting colour. Occasionally white lead is present.

The lead chromes are pigments of considerable brilliance of hue, while their staining or colouring power and body or covering power is great, being superior to that of any other yellow pigment. When well made they are fairly durable pigments, resisting exposure to most atmospheric influences. Sulphuretted hydrogen and sulphur compounds tend to turn them black, owing to the formation of sulphide of lead. Generally the chromes may be mixed with other pigments without being affected or bringing about any change, the only exceptions being with such colours as ultramarine and cadmium yellow which contain sulphur; such mixtures have a tendency to change their shade, becoming darker. Chrome yellows cannot be used with silicate of soda, lime or other vehicles of a highly basic or alkaline character, inasmuch as then they tend to turn orange or red.

Chrome yellows, oranges and reds, on account of the great variety of tints in which they occur and of no two makers' shades being exactly alike (even if they bear the same name), should be examined for the tint, covering power or body and staining power by the well-known methods. A chemical analysis of chrome yellows is rarely required; when such is the case the following scheme may be used:—

*For Moisture.*—Weigh out 2 grammes, dry in an air oven at 110° to 120° C. for a few hours, then weigh. The loss of weight gives the amount of water present.

*For Lead.*—Weigh out 2 grammes of the chrome, add 10 to 15 c.c. of strong sulphuric acid, heat until the chrome is completely decomposed, then allow to cool, dilute with water, add a little alcohol, filter and wash the precipitate well, mixing the first wash waters with the main filtrate. Then dry and weigh the precipitate in a porcelain crucible. This precipitate or residue will, if the chrome be pure, consist of lead sulphate, $PbSO_4$; but if the chrome contains barytes or china clay the residue will contain those bodies also; the amount of these (as ascertained by another experiment) is deducted from the weight found, to obtain the weight of lead sulphate present. By multiplying the weight of lead sulphate by 0·736 the amount of lead oxide it contains may be ascertained.

*For Chromium.*—Boil the filtrate from the lead sulphate until it is free from alcohol, then add ammonia in slight excess, boil the mixture well until the liquor is colourless;

filter, wash, dry and weigh the precipitate of chromium oxide which is obtained. By multiplying this weight by 4·23 the amount of lead chromate in the sample may be calculated. By multiplying by 2·9 the corresponding weight of lead oxide can be calculated.

*For Lead Sulphate and Barytes.*—Weigh out 2 grammes of the pigment and boil with strong hydrochloric acid until the chrome is completely decomposed; any insoluble matter is barytes or china clay; this is filtered off, washing thoroughly with boiling water, then dried and weighed as usual. The filtrate is then boiled and barium chloride is added; this throws down all the sulphate present as barium sulphate: the precipitate is filtered off, well washed with boiling water, dried and weighed. From its weight the quantity of lead sulphate can be calculated by multiplying by 1·16. It is important in the operations here noted to filter while boiling and to wash with boiling water.

*For Whiting.*—If this be present the amount may be ascertained by taking 2 grammes, treating with dilute nitric acid, filtering off any insoluble matter, then adding ammonia, filtering off any precipitate which may be obtained; then adding to the filtrate a few drops of ammonia sulphide to throw down any lead which may be present, filtering this off and adding ammonium oxalate to the filtrate: the mixture is placed on one side for twelve hours to allow the calcium oxalate time to settle out; then the precipitate is filtered off, washed, dried and weighed; its amount gives at once that of the whiting or calcium carbonate present in the sample.

*For Gypsum.*—If this be present its amount can be estimated as follows: Take 2 grammes and boil well with moderately dilute hydrochloric acid; then add dilute sulphuric acid to the mixture, filter off any precipitate which may be obtained, then add ammonia (should any precipitate come down, filter it off) and ammonium oxalate to the filtrate; this throws down the calcium as oxalate; the precipitate is collected, washed, dried and weighed, and from the amount of calcium carbonate so obtained the weight of calcium sulphate can be calculated by multiplying by 1·36.

The following are some analyses of "pure" chrome pigments made by the author:—

ANALYSES OF "PURE" CHROME PIGMENTS.

| | "Pure" Primrose Chrome. | "Pure" Pale Chrome. | "Pure" Middle Chrome. | "Pure" Deep Chrome. | "Pure" Orange Chrome. |
|---|---|---|---|---|---|
| Water and volatile matter . . . | 6·64 | 2·68 | 1·89 | 4·64 | 3·42 |
| Lead chromate, $PbCrO_4$ | 57·06 | 58·39 | 77·64 | 75·62 | 64·30 |
| Lead sulphate, $PbSO_4$ | 36·30 | 38·93 | 20·47 | 19·74 | 32·28 $PbO$ |

Cologne yellow and American yellows are simply chrome yellows made in a particular way. American yellows sometimes contain alumina from having been made with alum.

**CHROMIC ACID** is the commercial name of the chromium trioxide or chromium anhydride, $CrO_3$, which is prepared from potassium bichromate by means of sulphuric acid. It occurs in carmine-red, rather small crystals which are somewhat hygroscopic and easily soluble in water; this solution is acid in character and reacts with caustic potash and soda (or other basic solutions) to form chromates; the solution in water may be regarded as one of true chromic acid, $H_2CrO_4$, the existence of which in a free condition has not yet been definitely ascertained. It is a powerful oxidising agent owing to the facility with which it can be reduced to the basic condition. On this account it is employed in the preparation of many organic compounds, alizarine, etc. Heated with sulphuric acid it is gradually decomposed, oxygen being evolved and chromium sulphate formed. Heated with hydrochloric acid, chlorine is evolved and chromium chloride formed.

**CLAY** is the name given to earthy deposits found in a great many places. It is soft and unctuous to the touch; when moistened with water it develops great adhesive properties and can be moulded into a variety of forms. Clays are sedimentary deposits found in layers in other rocks of all ages. Chemically they consist essentially of hydrated silicate of alumina (see *China Clay* above), but in combination with other substances, such as lime, magnesia, oxide of iron, potash, etc. In colour they vary very considerably; some are white, others grey, some yellow, some of a bluish tint.

They are supposed to be derived from the decomposition of the felspathic constituent of granite or similar rocks. The felspar of these is a double silicate of alumina and potash or other alkaline metal: when exposed to the destructive influences of the weather, the carbonic acid and water gradually bring about the decomposition of the felspar; the alkaline constituent is dissolved away in the form of carbonate, while the silica and alumina unite with water to form a hydrated silicate of alumina; if this remains in the place where it is formed, then it keeps fairly pure and forms china clay or kaolin; while if it be washed away and deposited in some other place along with other constituents, it then forms the basis of the numerous deposits of clay.

Clays when heated to 100° C. (212° F.) lose their hygroscopic water, but the dried clay will again re-absorb it when brought into contact with water. If heated to a red heat, they lose their water of hydration; those which contain oxide of iron or iron minerals, change colour, turning red, a change which is seen during the making of bricks, red pottery, etc. The exact tint depends upon the amount of iron present; and may range from a cream or buff, when the proportion of iron is from 1 to 1½ per cent. to a light red with 3 to 5 per cent., or a dark red with larger quantities. Much, of course, depends upon the character of the other constituents in the clay. Clays which contain much lime, magnesia, potash or soda, are liable to fuse or melt when strongly heated, while those containing an excess of silica are not so liable to fuse.

Plasticity is the most essential feature of clays, and unless they possess this feature in a marked degree they are not very serviceable.

There are many varieties of clays, not differing much in their chemical composition, and showing a tendency to pass by small degrees one into the other. China clay has already been dealt with; pipe clay will be found described further on (see *Pipe Clay*), and other clays are noticed below.

The following are some analyses of fire clays:—

### ANALYSES OF FIRE CLAYS.

| | Stourbridge Clay. Per Cent. | Dowlais Clay. Per Cent. | Etherley Clay. Per Cent. | Glenboig Clay. Per Cent. | Eisemberg Clay. Per Cent. |
|---|---|---|---|---|---|
| Silica, $SiO_2$ . . . . | 65·10 | 67·12 | 55·61 | 57·57 | 64·72 |
| Alumina, $Al_2O_3$ . . | 22·20 | 21·18 | 27·50 | 26·35 | 24·02 |
| Magnesia, MgO . . | 0·18 | — | 0·79 | 0·55 | 0·40 |
| Lime, CaO . . . . | 0·14 | 0·32 | 0·32 | 0·60 | 0·37 |
| Potash, $K_2O$ . . . | 0·18 | — | 0·81 | 0·48 | 2·40 |
| Iron oxide, $Fe_2O_3$ . | 1·92 | 1·85 | 1·91 | 1·33 | 0·87 |
| Phosphoric acid . . | 0·06 | — | — | — | — |
| Water (combined) . | 7·10 | 7·41 | 12·42 | 13·75 | 7·38 |
| „ (hygroscopic) | 2·18 | — | — | — | — |
| Organic matter and loss on ignition . | 0·58 | — | — | — | — |

**Fire Clays** are deposits of clays of a very refractory nature, usually found underlying seams of coal, and hence frequently known as *under clays.* They vary a little in colour, but usually have a greenish-grey tint, which, on long exposure to the air, tends to turn yellowish. The best known fire clays are those found at Stourbridge in Staffordshire, but similar clays are also found in other counties. Fire clays should be as free from lime and magnesia as possible, as the presence of these bodies detracts from their heat-resisting properties.

**Pottery Clays.**—A good many deposits of clay are found which are extensively employed in the manufacture of common earthenware articles, flower pots, mugs, pans, etc. These are known under a variety of names.

**Ball or Plastic Clay** is much used for the cheap wares which are glazed with salt. One such clay had the composition:—

| | Per Cent. |
|---|---|
| Silica | 66·68 |
| Alumina | 26·08 |
| Oxide of iron | 1·26 |
| Lime | 0·84 |
| Magnesia | trace |
| Water | 5·40 |

A sample of red clay much employed for making the brown earthenware contained:—

| | Per Cent. |
|---|---|
| Silica | 49·44 |
| Alumina | 34·26 |
| Oxide of iron | 7·74 |
| Lime | 1·48 |
| Water | 5·14 |
| Magnesia | 1·94 |

The common yellow clay found in so many places has the composition shown in the following analysis:—

| | Per Cent. |
|---|---|
| Silica | 58·07 |
| Alumina | 27·38 |
| Oxide of iron | 3·30 |
| Lime | 0·50 |
| Magnesia | trace |
| Water | 10·30 |

It is probable that in many of the yellow clays, and in some others, the iron is present in the ferrous condition to a great extent.

**Blue Clay** is a clay of greyish colour which is much employed in the making of common pottery; it burns white or nearly white, and has the composition shown by the following analysis:—

| | Per Cent. |
|---|---|
| Silica | 46·38 |
| Alumina | 38·04 |
| Oxide of iron | 1·04 |
| Lime | 1·20 |
| Magnesia | trace |
| Water | 13·57 |

**Marls** are clays containing a large proportion of carbonate of lime; they are sometimes employed in making common pottery.

**Chemical Analysis of Clays.**—Before making an analysis, the sample of clay is allowed to dry by exposure for twenty-four to forty-eight hours to the air, then it is powdered as finely as possible.

*For Hygroscopic Water.*—Two grammes of the clay are weighed into a small crucible and kept in a hot oven at from 100° to 110° C., until no further loss of weight is experienced. The loss is the *hygroscopic water*. The sample of clay may now be strongly heated over a Bunsen burner for an hour and then reweighed. The loss shows the amount of *combined water*.

*For Silica, Alumina, etc.*—Two grammes of the powdered clay are heated in a basin with an excess of strong sulphuric acid for eight to ten hours, after which the solution or substance is evaporated to dryness. When cold, the residue is boiled with water and the mixture filtered. The insoluble matter (which consists of the sand, free hydrated silica and the silica which was in combination with the alumina of the clay) is washed with water, dried and weighed. It is then boiled with a solution of sodium carbonate, which dissolves out the free and combined silica, leaving the sand, which is then filtered off, washed, dried and weighed; the weight so ascertained gives the weight of the free and combined silica. Titanium oxide is sometimes present in clays, and is found in the insoluble residue from the sulphuric acid. It may be estimated by taking the residue from the sulphuric acid with a mixture of hydrofluoric and sulphuric acids, when the silica is converted into silicon fluoride and passes away The residue is then fused with potassium bisulphate, dissolved in cold water, and, after filtering off any insoluble matter, precipitating the titanium oxide, filtering, drying and weighing. It is rarely, however, that an estimation of the amount of titanium oxide in clays becomes necessary.

The solution from the residue of silica is taken and an excess of lead nitrate added, which causes the precipitation of lead sulphate; the mixture is allowed to stand for some time, then filtered, and the excess of lead in the filtrate thrown down by sulphuretted hydrogen: the lead sulphide so obtained is filtered off, the solution evaporated to dryness and the residue ignited until all the nitric acid is decomposed. What is now left consists of alumina, ferric oxide and the nitrates of calcium, magnesium, and of the alkali metals. It is treated with hot water and the residual alumina and ferric oxide filtered off, dried and weighed. To determine the proportion of iron oxide, the residue is digested with strong hydrochloric acid until dissolved, then pure caustic potash is added in excess and the mixture boiled, then filtered, and the residual oxide of iron well washed, dried and weighed; the weight deducted from that found for the iron and alumina together gives the weight of the alumina above.

To the filtrate from the alumina and iron, ammonium oxalate is added, and the mixture allowed to stand for twelve hours; the lime is thereby thrown down in the form of calcium oxalate; this is filtered off, washed, dried and weighed, either as carbonate or oxide of calcium. The filtrate from the calcium oxalate precipitate is evaporated down to dryness and heated until all ammoniacal fumes have been given off; a little oxalic acid and water is added, and the mixture evaporated down and ignited, whereby the magnesium present is converted into oxide, and the alkaline constituents into carbonates; the residue is treated with water, the insoluble magnesia filtered off and weighed, while the filtrate is acidified with hydrochloric acid and, after evaporation, the alkalies present are weighed as chlorides. See *How to Analyse Clay*.

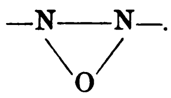
**COAL BLACKS,** black pigments prepared from coal and coal shale by grinding. They are but little used.

**COAL-TAR COLOURS.**—There are now a great variety of dyestuffs and colouring matters made from coal tar, or rather from various products which are derived, directly or indirectly, from coal tar; those which are commercial products number hundreds, while the number of known colouring matters must be considerably over a thousand. According to their chemical composition they may be divided into the following groups:—

1. **Nitro Colours.**—This group of dyestuffs is characterised

by containing the group $NO_2$, and includes those prepared by treating phenols and amines with nitric acid, such as picric acid, Naphthol yellow, Victoria yellow, Aurantia, etc. They dye animal fibres from acid baths, generally in various shades of yellow or orange, the shades not being remarkable for fastness to light, etc. They may be used for colouring varnishes, oils and similar products, but do not make lake pigments.

2. **Azoxy Colours.**—This group is but a small one, and is characterised by its members containing the group



Sun yellow and Mikado orange are the best known representatives of this group. They dye all fibres without a mordant, in shades which possess a certain degree of fastness.

3. **Hydrazine Colours.**—There is only one known member of this group, Tartrazine, which contains the group $=N—NH$. Tartrazine is an acid-dyeing colouring matter.

4. **Azo Colours.**—This is by far the largest and most important group of dyestuffs known, and the number is being continually added to. The group comprises dyestuffs capable of dyeing all textile fibres in almost every known shade and of every degree of fastness; the group comprises among its members some of the fastest and some of the most fugitive dyestuffs known. The group may be subdivided into several sub-groups of colouring matters whose properties as dyestuffs vary considerably.

The azo colours are characterised by containing the peculiar group of two nitrogen atoms represented in the formula $—N{=}N—$ the *azo group* as it is called. Some dyes contain one such group, when they are called the *monoazo* dyes;

others contain it twice, and of such there are two divisions, one known as the *disazo* colours and the other as the *tetrazo* colours, the latter being derived from diamines. Other dyes contain the group three times, and are known as *triazo* colours, while a few are known which have four azo groups, and are called *tetrakisazo* colours. The azo colours are formed from amines or amido compounds, which contain the group $NH_2$, monamines when it occurs once, or diamines when it occurs twice. The aromatic amines and amido compounds have the property of becoming *diazotised* as it is called when they are treated with a mixture of sodium nitrite and hydrochloric acid in the cold, the nitrogen atoms of the amido group on the one hand, and of the nitrous acid from the nitrite on the other, combine to form the azo nitrogen group previously spoken of. This group of two atoms is a fairly stable one. If united on the one hand with an aromatic radicle and on the other with chlorine or nitroxyl, by its two free affinities, it forms the compounds known as *diazo compounds*, and it is on this account that the operation is spoken of as diazotisation. The diazo bodies are unstable, but they possess the property, when brought into contact with solutions of phenols or amines and their compounds, of combining with them and then forming the azo compounds, most of which are colouring matters.

The azo dyes can be divided into the following subgroups:—

(*a*) *Amido Azo Dyes.*—This group is small in number. Its members are characterised by containing one or more free amido groups, which imparts to them basic properties. They include Aniline yellow, Bismarck brown and Chrysoidine. These dyestuffs are applied to cotton which has been previously mordanted with tannic acid, while they dye wool silk and all other animal fibres directly. They are precipitated by means of tannic acid, and, therefore, they may be used to make lake pigments.

(*b*) *Azo Dyes Proper.*—These are very numerous. They dye wool and silk from acid baths; they have little affinity, if any at all, for cotton. Many of them are precipitated from their solutions by such metallic salts as lead acetate, barium chloride, sulphate of alumina, etc., and hence may be used for making lake pigments. For this purpose those dyes which contain only one sulphonic group, $HSO_3$, give the best results. It may be mentioned here that two classes of azo dyes are known. One, the simplest, includes the substances (insoluble in water) which are produced by diazotising an amine and combining the product with a phenol or an amine. These are not used as dyes, because it is essential that a dyestuff should be soluble in water; they might be employed as lake pigments, but hitherto little if anything has been done with them in this direction. The soluble azo dyes are essentially produced from the insoluble ones by sulphonating them or by using the sulpho acids of the amines or phenols in making them.

(*c*) *Direct Dyeing Azo Colours.*—This class, which is now a numerous one, possesses the property of dyeing cotton and other vegetable fibres without a mordant, as also wool and silk from neutral baths. Most members of this sub-group are derived from diamines, like benzidine, tolidine and similar bases, but other amido compounds yield them. On what feature in their composition or constitution this power of directly dyeing cotton depends has not yet been satisfactorily established.

(*d*) *Mordant Dyeing Azo Colours.*—A small but increasing group of azo colours which have the property of forming insoluble colour lakes with chromium, aluminium and iron mordants, and are in consequence much used in wool dyeing and calico printing; they may be used in lake making. This sub-group includes such dyes as Alizarine yellow, Diamond yellow, Chrome yellow, Chrome green, Chrome red, etc.

5. **Nitroso Colours.**—This class of dyestuffs is a small one, and is characterised by containing the group NO. It includes such dyes as Gambine, Resorcine green, Dioxine, Naphthol green B. With the exception of the last named (which is an acid-dyeing colour) they are mordant-dyeing colouring matters, and are applied in wool and silk dyeing and in calico printing with the aid of chromium and iron mordants. They may also be used in making lake pigments (which, however, are not very bright) with the aid of chromium and iron salts.

6. **Oxyketone Colours.**—A group of dyestuffs comprising Alizarine yellow, Anthracene Yellow, Galloflavine, Alizarine, Anthragallol, etc, which contain one or two ketonic groups of CO atoms with two or more groups of hydroxyl, HO atoms. These dyestuffs possess little or no colour of themselves, but they form with metallic oxides (like those of chrome, iron or alumina) insoluble colour lakes, hence they are extensively employed in dyeing wool, silk and cotton and in printing textile fabrics; they give colours which possess a high degree of fastness to light, air, etc. They may also be employed in making lake pigments with the aid of chromium, aluminium or iron salts.

7. **Diphenylmethane Colours.**—A small group comprising Auramine, Acridine red and Pyronine, which are derived from the base diphenylmethane, $CH_2(C_6H_5)_2$. They are basic colouring matters, dyeing tannin-mordanted cotton, while wool and silk are dyed direct. With tannic acid they give precipitates so that they may be used for making lake pigments.

8. **Rosaniline Colours.**—A series of dyestuffs of a basic character dyeing tannin-mordanted cotton, while the animal fibres are dyed directly from neutral baths. This group

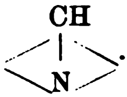
[illegible] green. Hof-[illegible] Victoria [illegible]. They are [illegible] acid in [illegible]

[illegible] member [illegible] resembles [illegible] applied in [illegible] soluble [illegible] of [illegible] converted [illegible]

[illegible] which [illegible] Its mem-[illegible] Methylene [illegible] dyeing [illegible] matters. [illegible] dyeing [illegible] dyes [illegible] used [illegible]

[illegible] dyes [illegible] Its members dye [illegible] tannic acid, while [illegible] They may be [illegible]

[illegible] Colours [illegible] dyes comprising [illegible] These dyes are of [illegible]

[illegible] Colours [illegible] a few basic dyes, Acridine yellow, Phosphine, Benzoflavine, which contain the group  These dyes are applied to the various fibres in the same manner as other basic dyes.

14. **Thiobenzene Colours.**—A group of dyes many of which are capable of dyeing cotton direct, while others have basic properties. They contain sulphur. Thioflavine, Primuline, and one or two others belong to this group.

15. **Dyestuffs of Unknown Composition.**—Canarine, New grey, Nigrosine, Phenyl brown, and a few others are included in this group.

Independently of their chemical composition, and having regard more to their practical application in textile colouring, etc., the coal-tar colours may be divided into four groups, as follows:—

1. The **Benzidine or Direct Dyeing Colours**, whose characteristic feature is that they will dye unmordanted cotton from a boiling bath of salt or other alkaline compound. As a rule, this class of dyestuffs, which comprises such dyes as Benzopurpurine, Titan scarlet, Titan yellow, Diamine red, Diamine brown, Oxyphenine, Clayton yellow, Turmerine, etc., cannot be used in the manufacture of lake pigments because many of them, *e.g.*, Congo red, Benzopurpurine, Azopurpurine, Chrysamine, etc., are much changed in shade by metallic salts, while as a whole they are rather fugitive to light. Their solubility in alcohol is but slight, so that they cannot well be used for colouring spirit varnishes.

2. **Basic Colouring Matters.**—This is a most important group of dyestuffs; the special characteristic of its members is that while they will dye wool and silk directly from neutral baths, they require cotton and other vegetable fibres to be mordanted with tannic acid. This group of dyes includes

Magenta, Safranine, Bismarck brown, Nigrosine, Soluble blue, Nile blue, Basle blue, Thioflavine T., Benzoflavine, Auramine, Chrysoidine, Phosphine, Quinoline yellow, Rhodamine, Methyl green, Paris violets, Methyl violet, Induline, etc. These dyes give precipitates with tannic acid, and hence may be used for making lake pigments. They are usually easily soluble in alcohol, and are therefore very much used in colouring spirit varnishes, lacquers, etc. Generally they are not soluble in petroleum or turpentine or oil, hence they cannot well be used for colouring oil varnishes; but the free bases of some of them have the property of being soluble in oil, and these are made as commercial articles and sold as oil colours for colouring fatty matters and oil varnishes. Some of the dyes of this group (Induline, Nigrosine, Opal blue, Quinoline yellow) occur in two forms, one insoluble in water but soluble in spirit, the other soluble in both water and spirit. The first variety is often used for colouring spirit varnishes.

3. **Acid Colouring Matters.**—The dyestuffs of this group are characterised by dyeing wool and silk in acid baths; they have little or no affinity for cotton and other vegetable fibres. They are divisible into several sub-groups as follows:—

(*a*) The **Eosines,** a class of colouring matters derived from fluorescein, and characterised by dyeing scarlets of various hues of a very bright character, which are, however, rather fugitive. They are readily soluble in alcohol and water, and their solutions are characterised (especially the alcoholic ones) by having a strong fluorescence, varying in tint and strength with different eosines. Thus Eosine G. has a yellowish-green, Safrosine, a faint yellowish-green, Phloxine a light green, Erythrine a green-yellow, Eosine J. a strong green-yellow, Cyanosine an orange-yellow, and Chrysoline a yellowish-green fluorescence in both the aqueous and alcoholic solutions, the fluorescence in the latter case being the strongest. Rose Bengale has no fluorescence in the aqueous solution, but a strong golden-yellow one in the alcoholic solution. Erythrosine has only a trifling fluorescence. They dye wool and silk in colours which are very bright, but very fugitive to light. With metallic salts (like lead acetate, sulphate of alumina, and acetate of chrome) they form colour lakes, and hence are applied in calico printing by using metallic salts like those named. They are much used in making such pigments as vermilionettes, royal reds, imperial reds, etc., using lead acetate or sulphate of alumina as precipitating agents.

(*b*) **Nitro Colours** are exemplified by Naphthol yellow, picric acid, Aurantia, etc. They are mostly yellow or orange dyes, and are used in dyeing both silk and wool; they are also employed in colouring varnishes, being soluble in alcohol and oil.

(*c*) **Acid Colouring Matters** comprise Acid Magenta, Acid green, Acid violet, Acid blue, etc. They are mostly sulphonated basic dyes capable of dyeing wool and silk from acid baths. Some of them can be precipitated by barium chloride or by a mixture of barium chloride and tannic acid; they can, therefore, be employed in making lake pigments. Some of them are soluble in alcohol and oil, and may therefore be used in colouring varnishes.

(*d*) **Azo Colours.**—See page 110, where this class of colours are mentioned. It may be added here that, being soluble in alcohol, they may be used in colouring varnishes with good results.

4. **Mordant-dyeing Colouring Matters.**—Alizarine, Galleine, Anthracene brown, Gambine, Dioxine, Chrome Bordeaux, Chrome violet, Galloflavine, etc., belong to this group. See oxyketone colours, page 113, and mordant-dyeing azo colours, page 112.

The following table shows the solubility of many of the coal-tar colours in alcohol or methylated spirit:—

1. Colouring matters *soluble in water and spirit*:—

| | | | |
|---|---|---|---|
| Magenta | Acid magenta | Vesuvine | Iodine green |
| Cardinal | Cerise | Rubine | Crimson |
| Erythrosine | Rose Bengale | Methyl eosine | Eosine |
| Safranine | Coccine | Phloxine | Corallin |
| Methylene blue | Peacock blue | Navy blue | Benzyl blue |
| Picric acid | Naphthol yellow | Phosphine | Aurantia |
| Curcumine | Brilliant yellow | Auramine | Chrysophenine |
| Metanil yellow | Methyl orange | Chrysoidine | Mandarin |
| Hofmann violet | Regina purple | Methyl violet | Acid violet |
| Malachite green | Brilliant green | Acid mauve | Methyl green |
| Bismarck brown | | | |

2. Colouring matters *soluble in water only*:—

| | | | |
|---|---|---|---|
| Congo | Heliotrope | China blue | Brilliant scarlet |
| Congo corinth | Brilliant blue | Regina violet | Acid yellow |
| Brilliant congo | Wool blue | Azo violet | Resorcin yellow |
| Benzopurpurine | Black blue | Fast brown | Quinoline yellow |
| Deltapurpurine | Benzoazurine | Acid brown | Azo acid yellow |
| Roseazurine | Azo blue | Resorcin brown | Chrysamine |
| Hessian purple | Guernsey blue | Guinea green | Hessian yellow |
| Fast red | Hessian blue | Aniline grey | Curcumein |
| Archil red | Water blue | Nigrosine | Orange |
| Ponceau | Bavarian blue | Silver grey | Rubine S. |
| Scarlet | Capri blue | Wool black | Nacarat |
| Azo rubine | Alkali blue | | |

Some of these colours are soluble in spirit, but their degree of solubility is too slight to be of much service.

3. Colouring matters *soluble in spirit only*:—

| | | | |
|---|---|---|---|
| Rosaniline base | Aurine | Soudan | Spirit blue |
| Nigrosine, spirit soluble | Malachite green base | Brilliant black<br>Ebony Black | Induline, spirit soluble |
| Humboldt blue | New violet | Auramine base | |

4. Colouring matters soluble in oil:—

| | | | |
|---|---|---|---|
| Rosaniline base | Violet base | Soudan I. | Soudan II. |
| Magenta base | Auramine base | Picric acid | Oil green |
| Oil yellow | Oil violet | Oil orange | Oil crimson |
| Butter yellow | Oil brown | Oil scarlet | |

Practically none of the coal tar colours are soluble in petroleum or petroleum spirit, or in turpentine.

For a fuller account of the composition and properties of coal-tar colours, the reader is referred to Knecht & Rawson's *Manual of Dyeing*, and to the author's *Dictionary of Coal Tar Colours*. For a description of the methods of using them for making lake pigments, reference may be made to the author's *Manual of Painters' Colours, Oils and Varnishes*.

**COAL-TAR NAPHTHA.**—When coal tar is distilled the first portions of the distillate, "first runnings" as they are called, is a light pale-coloured and rather volatile liquid. This when distilled yields benzols and "naphtha," four fractions being usually obtained, 90's benzol, 50/90's benzol, solvent naphtha and burning naphtha ; sometimes other fractions are produced, inasmuch as the practice of tar distillers varies somewhat.

Burning naphtha has usually a specific gravity of 0·880 to 0·887, and is largely employed for burning in costermongers' lamps, although for this purpose it has been largely displaced by petroleum.

Solvent or coal-tar naphtha is largely employed in the rubber industry, in varnish making and paint making. As commonly sold it is a water-white liquid, with occasionally a yellow tint ; it has a peculiar and characteristic odour. Its specific gravity varies from 0·865 to 0·877. On being subjected to distillation it gives from 8 to 30 per cent. of distillate below 130° C., while generally 90 per cent. distils below 160° C. It is very inflammable, burning with a luminous but smoky flame. The flash-point is about 120° F. It is miscible with ether, alcohol, turpentine, petroleum spirit, shale naphtha and other similar liquids. It is a good solvent for oils, fats, resins, waxes, and is almost the only solvent for coal-tar pitch and pitches in general.

In composition it is very complex, but it consists chiefly of the three isomeric ortho-, para- and meta-xylenes, $C_8H_{10}$, cumenes, $C_9H_{12}$, small quantities of paraffins and olefins, and, occasionally, a little naphthalene. Sulphuric acid has little action on coal-tar naphtha; strong nitric acid has a powerful action and converts the coal-tar hydrocarbons into nitro derivatives, nitro xylene, $C_8H_9NO_2$, nitro cumene, etc. Hydrochloric acid, caustic soda and caustic potash have no action on coal-tar naphtha.

Commercial coal-tar naphtha is often adulterated by petroleum, or shale spirits, or by petroleum and shale-burning oils; in such cases the specific gravity is materially reduced. The addition of petroleum or shale spirit causes it to distil at lower temperatures, and the rise of temperature during the operation is rather more regular. The addition of burning oils raises the temperature of distillation somewhat.

The best method of examining coal-tar naphtha for its quality is by distillation. A method commonly used is the following: 100 c.c. of the naphtha to be tested is measured, by means of an accurate glass measure, into a tubulated retort of 200 c.c. capacity, through the tubulure of which a thermometer is inserted, the bulb of which reaches within three-eighths of an inch from the bottom of the retort. The beak of the retort is connected with a Liebig's condenser and the distillation is carried on by means of a Bunsen burner. It is best to set the retort in a deep sand-bath, so that, if the retort should crack, the naphtha will be run into and be harmlessly absorbed by the sand; whereas if the retort was heated directly by the flame of the burner, a disastrous effect would be produced. The temperature at which the first drop falls from the end of the condenser is noted; this, with naphtha, usually occurs at about 110° C.; then the rate of distillation is noted: at 120° C. about 20 per cent. will usually distil over, at 130° C. about 60 per cent., at 140° C. about 72 per cent., while 90 per cent. usually distils over below 150° C. Another plan is to note the temperature at which each 10 c.c. of distillate comes over. In this case the results will be something like the following: 10 c.c. or 10 per cent. at about 128° C., 20 per cent. at 130° C., 30 per cent. at 132° C., 40 per cent. at 135° C., 50 per cent. at 137° C., 60 per cent. at 140° C., 70 per cent. at 145° C., 80 per cent. at 148° C., 90 per cent. at 150° C. Addition of petroleum or shale spirits will increase the proportion of spirit or naphtha distilled at the lower temperatures (see *Benzoline*); while the addition of petroleum or shale-burning oils will increase the proportion distilling at high temperatures. Sometimes the makers take out the lower boiling portions of the naphtha and thereby affect the distillation test somewhat.

The addition of paraffin or petroleum products to coal-tar naphtha may be detected as follows: Take 50 c.c. of the sample and treat with a well-cooled mixture of nitric and sulphuric acids; this converts all the coal-tar hydrocarbons into nitro compounds, while the paraffin or petroleum hydrocarbons are unaffected. When all action has apparently ceased pour the mixture into water; the nitro compounds will sink to the bottom, leaving the paraffin or petroleum hydrocarbons on the top of the water; they may then be collected and measured. It should be pointed out that finding only a small amount of such unchanged hydrocarbons does not necessarily indicate adulteration, as coal-tar naphtha naturally contains small quantities of paraffin hydrocarbons.

**COBALT BLUE.**—This pigment is a compound of the oxides of alumina and cobalt, its average composition being shown by the following analysis:—

| | Per Cent. |
|---|---|
| Water . . . . | 3·07 |
| Alumina, $Al_2O_3$ . . . | 80·80 |
| Cobalt oxide, CoO . . | 15·13 |
| Alkaline salts . . . | 1·00 |

It is a pigment of a very fine greenish-blue tint; there is, however, a tendency for it to assume a violet tint under the influence of gaslight. It is quite permanent when exposed to light and air, and hence is largely used by artists, especially by workers in water colours, inasmuch as it gives better results with water as a vehicle than with oil. Cobalt blue can be mixed with all other pigments without affecting them or being altered by them in any way. Neither alkalies nor dilute acids have any material action on it, but a solution can be obtained by long digestion with strong hydrochloric acid. On being heated with strong sulphuric acid for some time it is decomposed, a violet solution and a white powdery residue being obtained; on dilution with water the latter dissolves and a clear blue solution is obtained, which can be examined by the usual analytical methods.

Cobalt blue has been known under a variety of names, such as Thenard's blue, Gahn's ultramarine, cobalt ultramarine, etc.

**COBALT CARBONATE** is used in the colouring of pottery and glass. It is sold in the form of a pink powder, which contains:—

| | | | |
|---|---|---|---|
| 61 to 62 | per | cent. | cobalt oxide |
| 36 to 37 | ,, | ,, | carbonic acid |
| 3 to 1 | ,, | ,, | water |

It should be entirely soluble in hydrochloric acid, and such solution should not give precipitates on adding sulphuretted hydrogen or ammonia. On ignition cobalt carbonate is decomposed, leaving a black residue of cobalt oxide.

**COBALT GREEN,** also known as Rinman's green and zinc green, is a compound of the oxides of cobalt and zinc with, sometimes, the addition of a little phosphoric acid to heighten and brighten the colour. The following analyses given by Wagner will show the average composition of this pigment:—

| | Per Cent. | Per Cent. | Per Cent. |
|---|---|---|---|
| Zinc oxide, $ZnO$ | 88·040 | 71·93 | 71·68 |
| Cobalt oxide, $CoO$ | 11·622 | 19·15 | 18·93 |
| Phosphoric oxide, $P_2O_5$ | — | 8·22 | 8·29 |
| Ferric oxide, $Fe_2O_3$ | 0·298 | — | — |
| Soda, $Na_2O$ | — | ·69 | — |

Cobalt green has a bright green colour of a slightly yellow hue; those greens which contain phosphoric acid generally have a slightly bluer hue than those which do not contain it. It is perfectly permanent when exposed to light and air and is, on this account, a useful pigment; its cost, however, prevents it from coming into very extensive use. It can be mixed with all other pigments without affecting them in any way. Dilute acids and alkalies have no action on cobalt green; but strong acids decompose it, forming a blue solution, in which cobalt and zinc can be detected by the usual tests.

**COBALT OXIDE.**—This substance is a black powder, insoluble in water and dilute acids, but soluble in strong acids, forming blue or pink solutions. In composition it corresponds with the formula $CoO$. It is largely employed in the colouring of glass and pottery, owing to its producing a fine and permanent blue colour when in combination with phosphoric acid, silicic acid, etc. The commercial article is fairly pure, usually containing 95 per cent. of cobalt oxide. It is necessary that it should be free from any admixture with iron, nickel or copper oxides, the presence of which materially affects the purity of the colours produced with it. Cobalt oxide should answer to the following tests: It ought to be completely soluble in strong hydrochloric acid to a blue or pink solution. (It may be mentioned here that the colour of cobalt solutions vary with their strength, etc., and are sometimes blue and sometimes pink.) This solution should give no precipitate with sulphuretted hydrogen, nor with ammonia. The former test will serve to indicate the presence of copper, while the latter will show the presence of iron. The presence of nickel will be ascertained by the following test: Dissolve the sample in acid and neutralise it. Then add a strong solution of potassium cyanide until the precipitate which forms at first is re-dissolved. Heat until no further odour of cyanogen is perceived. Then allow to cool and add a solution of sodium hypochlorite, when, if any nickel be present, a black precipitate of nickel oxide will be obtained.

**COBALT PHOSPHATE** is employed in the colouring of pottery and glass. It occurs in the form of a bluish-white powder, insoluble in water, but soluble in acids. Its composition is shown in the following analysis of the commercial product:—

61 per cent. cobalt oxide, CoO
39 ,, ,, phosphoric oxide, $P_2O_5$

It is entirely soluble in acids, from which solution it is re-precipitated on adding ammonia.

**COBALT ULTRAMARINE** is a synonym of *Cobalt Blue*, which see.

**COCHINEAL.**—This important dyestuff is the dried remnant of the female of a species of *coccus* living on cactus plants in Central Mexico and the West Indies. Formerly cochineal was of great importance in the dyeing industry, being used for producing scarlets on wool; but of late years its use for this purpose has greatly diminished in consequence of the introduction of the azo scarlets from coal tar, which are much more easily applied and are cheaper.

The female cochineal insect, the *coccus cacti*, is wingless at first. It has six feet, but these become abortive and the insect fixes itself by means of a trunk between its forefeet to the leaves of the cactus plant, on the sap of which it lives. The male insect possesses wings and lives to fecundate the female, who soon lays some thousands of eggs, which cover its body and make it appear white. The female collects the eggs under her body, hatches them and dies. During the young, or larval, state the sexes cannot be distinguished. The whole life of the insect extends over three months.

Just before laying eggs the female insects are richest in colouring matter, and this is the time when they are collected. The collection is done by brushing them off the plant into boiling water, which instantly kills them. They are then laid out to dry in the sun. It has been estimated that 70,000 cochineal insects are required to make a pound of the commercial cochineal.

Several varieties of cochineal are recognised commercially, namely, "grey" and "black," which contain eggs; "shelly," which contains no eggs; and "silver," which is considered to be the best. Common cochineals are, however, often dusted over with talc or barytes to imitate silver cochineal. Besides the varieties here named a difference is sometimes made between the cochineal from Teneriffe and that from Mexico.

Cochineal contains a small quantity, about 1 to 2 per cent., of waxy matter, a little fat and about 10 per cent. of a colouring principle, which apparently possesses acid properties.

The properties of the colouring principle of cochineal were investigated by Warren de la Rue. It has the formula, $C_{17}H_{18}O_{1}0$, and has been named carminic acid, and considered to be a glucoside; that is, when boiled for some time with dilute acids it takes up the elements of water and forms a glucose sugar. Some recent investigations by Liebermann tend, however, to discredit this idea.

Carminic acid may be isolated from cochineal as a purple brown, friable mass, which, on grinding, can be converted to a red powder. It is soluble in water and alcohol in all proportions to a crimson solution. It is very slightly soluble in ether. It is soluble in hydrochloric and sulphuric acids. Nitric acid oxidises it, oxalic acid being among the products of decomposition.

With the alkalies it forms soluble salts of a dark red colour. With alumina, lead, copper and other metals, it forms insoluble coloured compounds, which are easily soluble in acid solutions. From neutral and alkaline solutions alumina and tin salts throw down scarlet precipitates. The acetates of lead, copper, zinc and silver throw down purple precipitates.

Cochineal is used in making carmine, crimson, Florentine, purple and other lakes.

**COERULEUM.**—Under this name two distinct pigments are known, one of modern origin, the other having some historic interest.

Messrs. Rowney & Co. make a pigment of a greenish-blue tint, which they sell as *coeruleum*. It is a compound of the oxides of tin and cobalt. Their method of preparation is kept secret. It is used solely by artists.

A blue pigment is found on the paintings and decorations of the ancient temples of Pompei, Alexandria, Cairo, and other ancient cities of Egypt, which serve to show that the ancient Egyptians had some knowledge of colour making. The secret of the preparation of this blue pigment has been lost. It has been examined by Sir Humphrey Davy and others without any result, so far as its mode of manufacture is concerned. Recently Fouque examined the pigment and gave its composition as :—

| | Per Cent. |
|---|---|
| Silica, $SiO_2$ | 63·7 |
| Calcium oxide, CaO | 14·3 |
| Copper oxide, CuO | 21·3 |
| Ferric oxide, $Fe_2O_3$ | 0·6 |

showing that it is probably a double silicate of calcium and copper, having the formula $4SiO_2$, CaOCuO. He has succeeded in making an imitation of it.

**COLCOTHAR** is the name given to the oxide of iron left behind when copperas is heated in a retort. See *Ferric Oxide, Iron Oxides.*

**COLOGNE EARTH.**—A brown pigment found in the neighbourhood of Cologne; it is very little used now.

**COLOGNE YELLOW,** the name given to pale shades of chrome yellow, is made by precipitating lead acetate with a mixture of bichromate of potash and sulphuric acid.

**COLOPHONY.**—The French name of *Rosin*, which see.

**COPAL.**—The name given to some hard resins found in various parts of the world and much employed in the manufacture of varnishes. Animi (which has already been described under *Animi*) is sometimes classed as copal. The typical copals come from the west coast of Africa, Sierra Leone being the great centre of the trade in this material.

So-called copals are also imported from the Philippine Islands, from South America, the West Indies; kauri also has been classed among the copals; but all these products cannot strictly be considered as copals, as their properties as varnish resins are quite distinct. It may be pointed out here that the term copal having been given to so many varieties of resin, and care not having been taken to distinguish them from one another, some confusion has arisen among writers on the subject.

The **true copals** are found along a narrow strip of the coast of West Africa, extending from 8° N. latitude to 4° S. latitude, a distance of some 700 miles. In this district the copal is found as a fossil in the ground at various depths up to 10 feet, or in the river beds of the district. The gathering is only done during the wet season which extends from March to May, the ground at this period (mostly comprised of strata of marl, sand and clay) being sufficiently soft to permit of its being easily dug into by the negroes, who use such primitive tools that they are ineffective in the dry season.

The botanical origin of copal is unknown. Some authorities assign it to a tree called *Guibourtia copallifera*, which is found growing inland and yields a fair supply of resin: no tree now growing on the coast yields the copal resin. The tree has evidently become extinct on the coast; possibly as the interior gets opened up to trade it may be discovered inland.

After the natives have collected it they carry it to the coast ports for export to Europe and America. The principal ports are Sierra Leone, from which the best copal is exported, Accra, Benin, Gaboon, Loango, Angola, the Congo ports and Benguela. There are some slight differences in external appearance between the copals from these ports, but none in their general properties.

*Sierra Leone copal* is the best quality imported into this country. It usually comes over in the form of rough angular pieces, almost colourless, or at the most having a faint yellow colour. It is hard, has a specific gravity of 1·054, and is quite insoluble in alcohol, ether, chloroform, etc. It melts at 205° C. (400° F.). When finely powdered, long digestion in ether (quite free from alcohol and water) causes a portion to dissolve; while the rest, amounting to about 64 per cent., simply swells up. When melted it gives off a small proportion of an oily liquid which contains a terpene, probably pinene; the residue, on cooling, will set into a hard brittle mass soluble in ether, turpentine, chloroform, etc. It is on this property of becoming soluble after being fused that the manufacture of varnishes from copals is based. This variety of copal is much used in making varnishes, yielding, as it does, a varnish which dries with a hard lustrous coat of a very durable character. By careful selection of the resin very pale varnishes may be made.

*Pebble copal* also comes from Sierra Leone; it occurs in small rounded pieces, varying slightly in size, but attaining to no great dimensions. Generally it is colourless, but some samples are slightly coloured, generally of a brownish-yellow tint. It is very hard, and is, perhaps, the hardest of the copals. Its specific gravity is 1·055. It is found in the beds of the rivers along the coast, and owes its pebble-like form to the wearing action of the water during its transit down the river. In its properties it resembles Sierra copal.

*Angola copal* is found in the three districts of which Angola, Benguela and the Congo are the centres. The copals found in these districts are so much alike that they are all classed together as "Angola copal" or, as it is sometimes called from its appearance, "red Angola copal". It is generally in the form of globular pieces, although flat pieces are met with. In size it usually ranges from 1½ to 2 inches, but large pieces of from 5 to 6 inches are met with occasionally. The characteristic feature of this variety of copal is that it is covered with a red crust of about one-sixteenth of an inch thick; this crust is probably due to the decomposing action of the soil on the resin; when this crust is removed, the resin is usually found to be free from colour or, possibly, it may have a faint yellow tint. It is a common thing to find enclosures in this resin, bits of bark, wood, insects, air bubbles, etc. Angola copal is usually not so hard as Sierra Leone copal or pebble copal, but it makes a good, hard and durable varnish. Its specific gravity is 1·065.

*Gaboon copal* is found in rounded, somewhat flattened pieces, varying in size from ½ inch to 2 inches; in colour it is the darkest of the copals, being usually of a sherry colour; consequently it is employed chiefly for making dark-coloured varnishes. The surface is usually smooth, but occasionally pieces are met with having a striated crust. Gaboon copal is fairly hard and makes a good varnish.

*Loango copal* differs from other copals in the manner in which it is found; in form it is often cylindrical, and, from their appearance, it is evident that the pieces have been broken off larger masses. Two varieties of Loango copal are known, named respectively *white* and *red;* the former ranges in colour from a colourless to a faintly yellow, the latter from a reddish to a faint brownish tint. It is also on the average, rather larger in size, more cylindrical in form, and more homogeneous; it is therefore considered the best. The red copal being rather harder than the white makes a more durable and more lustrous varnish.

The above varieties constitute those which are generally known as true copals; they are employed in making the best class of carriage and cabinetmakers' oil varnishes. The following resins are denominated copals, but only on account of similarity in appearance; they are different in their properties.

**Demerara Copal.**—This resin also known as locust gum and Guiana gum is imported from British Guiana. It is supposed to be the product of the locust tree, *Hymenea Courbarii.* It is found in the ground in much the same way as the African copals. As got it is covered with a thick crust of disintegrated resin; when this is scraped off the resin is found to have a lustrous appearance, is quite clear and transparent and perfectly homogeneous. In size it varies considerably; very large masses of 10 to 12 lb. weight are often found, while a piece weighing 60 lb. has been found. Demerara copal has a specific gravity of 1·030, melts at from 240° C. to 250° C. (450° F. to 465° F.). When heated it gives off a large proportion of volatile oil and gas, and does not leave so much solid resin behind as does animi or copal. On this account many varnish makers accustomed to copal have not found it to be so good a resin for making varnish, but if due allowance is made for the extra volatile matter this copal is a fairly good varnish resin. It is soluble in ether; alcohol causes it to swell to a white gelatinous mass; chloroform has a similar action, and further a portion is dissolved; petroleum ether causes it to swell and form a white jelly.

**Manila Copal.**—See *Manila Copal.*

**COPPERAS**, the commercial name of *Ferrous Sulphate*, which see.

**COPPER OXIDE.**—This substance is employed, in the preparation of pottery and porcelain, for the production of red and other colours. It is a black powder, having a composition corresponding to the formula, $CuO$. It is insoluble in water, but easily dissolves in acids, giving, as a rule, blue solutions and forming the corresponding copper salts. The commercial copper oxide is usually fairly pure. Copper oxide ought to answer to the following tests: It should dissolve fairly readily in hydrochloric acid, giving a green solution; there ought to be but a small portion insoluble. The solution ought not to give any precipitate on adding excess of ammonia. On passing sulphuretted hydrogen gas through the solution and filtering off the precipitate, no further precipitate should form on adding ammonia. The solution should give no precipitate on adding dilute sulphuric acid.

**CORNWALL STONE** is a partially decomposed granite of a white colour, and possessing vitrifiable properties. It is largely used in the manufacture of porcelain and pottery. The following are some analysis of Cornish stone:—

| | Per Cent. | Per Cent. | Per Cent. |
|---|---|---|---|
| Silica, $SiO_2$ . . . | 46·32 | 46·29 | 35·65 |
| Alumina, $Al_2O_3$ . . | 39·74 | 40·09 | 32·50 |
| Oxide of iron, FeO . . | 0·27 | 0·27 | 1·65 |
| Lime, CaO . . . | 0·36 | 0·50 | traces |
| Magnesia, MgO . . | 0·44 | — | traces |
| Water and alkali . . | 12·87 | 12·85 | 30·20 |

Compared with china clay it contains slightly less silica and more alumina, but it has not the same homogeneous structure. It is a mixture of kaolin, undecomposed felspar and quartz, with a little mica.

**CRIMSON LAKE** is a pigment prepared from cochineal by precipitating it with alum and soda. It is of a dark crimson colour, and is usually sold in small conical-shaped masses. It is mostly employed in decorative and artistic painting, but it is not permanent nor has it much body, therefore it forms what is known as a *glazing* or *tinting* colour.

**CROCUS** is a name sometimes given to the oxide of iron left as a residue when copperas is heated in a retort or other vessel. See *Iron Oxides.*

**CYPRUS UMBER** is the name given to the variety of umber found at Cyprus. Another name, and the one by which it is mostly known, is Turkey umber. See *Umber.*

## D.

**DAMMAR or GUM DAMMAR.**—Under the name of dammar there comes into this country several varieties of resins from Siam and neighbouring countries which are largely employed in the preparation of varnishes. The following varieties may be distinguished:—

1. **Singapore Dammar.**—This is generally considered to be the true dammar. It is derived from the Amboyna pine, *Dammara orientalis*, a tree which is indigenous to Malacca, Java, Sumatra, Borneo and neighbouring islands, in which places it chiefly grows in the hill districts. The great bulk of the dammar of commerce comes from Java through Singapore, from which circumstance it acquires its name of Singapore dammar.

The dammar exudes out of certain excrescences which grow a little above the root of the tree. In Java and Sumatra the resin is allowed to flow out naturally; in other localities the natives make incisions in the excrescences to promote the flow of the resin. Large quantities of the resin are also found in the beds of the rivers flowing through the regions where the tree grows. Some resin is also obtained from the branches of the trees. This has a somewhat different shape, being more cylindrical in form.

Singapore dammar comes into commerce in the form of nodular pieces varying in size from ½ an inch to 2 inches. Sometimes the pieces are covered with a powdery crust. The resin is clear and transparent, homogeneous in structure, nearly white in colour, which rarely exceeds a straw tint. It breaks easily. It is not as hard as Sierra Leone copal, but it is harder than resin. When fresh it has a peculiar balsamic odour, but this disappears on keeping. Its specific gravity varies from 1·062 to 1·123. Dammar is soluble in turpentine, ether, chloroform and oil. It is also soluble in petroleum spirit, in which respect it differs from the majority of the resins. Alcohol causes it to swell into a white gelatinous mass, a portion of the resin passing into solution. Amyl alcohol has a similar action to ordinary alcohol. Very little, however, is dissolved, the resin swelling to a white opaque mass.

2. **Penang Dammar.**—This variety comes chiefly from Penang and Batavia. It does not differ much from the Singapore variety, except that it comes in rather larger sizes. It is perhaps a little more soluble in the various solvents.

Dammar is used in making varnishes for coach and cabinet-makers with oil. Its solution in turpentine or benzol is used for making varnishes for pictures, paper and media for mounting microscopical objects. Dammar produces a varnish which has a pale colour, and dries with a hard coat. It has the defect of being rather friable, so that when dry varnish becomes powdery when rubbed with the fingers.

3. **Rock Dammar.**—This resin, which is almost indistinguishable from the last two varieties, is the produce of two species of *Hopea, viz.*, *Hopea odorata*, which grows in Burmah, about Rangoon, Pegu, Martaban and other localities, and *Hopea micrantha*, a native of the Malay States of Malacca, Sumatra and Borneo. There are some differences between

the resin yielded by these two trees. That from the *odorata* generally occurs in the form of rounded pieces about the size of walnuts, is pale in colour, while colourless pieces are often met with, the *micrantha* resin is rather larger, darker in colour, and harder. These two dammars are not distinguished from one another in commerce. As far as their uses and properties are concerned they resemble the Singapore and Penang dammars.

4. **Sal Dammar.**—This resin is not often met with in the English market, it being consumed almost entirely in India and the districts in which it grows. It is obtained from the Sal tree, *Shorea robusta*, which grows on the southern slopes of the Himalayas. It is also found in the hills of West Bengal, in Borneo, Sumatra and contiguous countries. It is generally found in long cylindrical and rather brittle pieces, of a pale cream colour. Some pieces are opaque, and many show streaks as if the pieces were formed by the flow of different streams of resin. It is rather heavier than the other dammars, its specific gravity ranging from 1·097 to 1·123. It is not so soluble in ether, turpentine, etc., as the other dammars, the solutions having a more or less turbid appearance. Its uses are the same as those of the other dammars.

5. **Black Dammar.**—Black dammar, or *lai dammar* as it is known in India, is principally derived from the tree *Canarium strictum*, which grows in the Tinnevolly district, but other species of *Canarium* also yield the resin. This resin is obtained from the trees by a process very different from that commonly adopted. The natives make a number of vertical cuts in the trunk of the tree, and then set fire to it below those cuts. The tree is then left for two years, by the end of which time a quantity of resin will have exuded from the tree, and is collected. From one tree some 200 lb. of resin

will be obtained. As its name would indicate black dammar occurs in the form of black or brownish-black pieces, which, as seen in the mass, have an opaque appearance, but when seen in thin slices are transparent. It is rather more soluble than the other dammars which are described above. It is readily soluble in turpentine and hot alcohol.

**DEMERARA ANIMI** or **DEMERARA COPAL** has been described under the head *Copal* on p. 131.

**DERBY RED.**—The basic chromate of lead is best known under this name, although it is also called American vermilion, Chinese red, chrome red, etc. In its chemical composition it is a basic chromate of lead, having the composition shown in the following analysis:—

| | Per Cent. |
|---|---|
| Moisture | 1·69 |
| Lead chromate, $PbCrO_4$ | 57·55 |
| Lead oxide, $PbO$ | 39·99 |

which corresponds to the formula $PbOPbCrO_4$.

It is made by digesting white lead with neutral or normal chromate of potash. It is a scarlet red powder of some brilliance of tone; it is heavy, its specific gravity being 6·26 It possesses good covering and staining power, although, being heavy, it is somewhat troublesome to work under the brush. Its tint is much affected by grinding, which turns it yellowish in colour. This is probably due to a breaking down of the crystalline structure which Derby red possesses. In its chemical properties it resembles *Chrome Yellow*, which see.

**DEXTRINE.**—See *British Gum.*

**DOUGLAS GREEN,** prepared by heating barium chromate with sulphuric acid, is a mixture of chrome oxide and barium sulphate. It is of no practical importance. See *Chemical News*, vol. xl., p. 59.

**DRAGON'S BLOOD.**—The ordinary dragon's blood of commerce is the produce of the *Calamus draco*, the tree which yields the familiar cane. This tree is a native of Eastern Asia, from places in which district the resin is sent in large quantities into the European markets. The fruit of this tree, on approaching maturity, becomes covered with a red friable mass, which is collected by shaking the fruits into baskets, and sifting the resin from stems and woody particles. The resin is melted by the heat either of the sun, or of a fire, or of boiling water, poured into moulds (usually formed out of a palm leaf), and then sent to the various ports for sale. Singapore, Batavia, and other ports close to are those from which dragon's blood finds its way into the London market. Dragon's blood occurs in cylindrical sticks of a rough form, 12 to 14 inches long, and from ½ inch to 1 inch thick; smaller pieces are common. As a rule, the sticks of dragon's blood are of a blackish-brown colour, and have an opaque appearance. When seen in thin slices it has a crimson colour and is transparent. Its specific gravity is about 1·2, but varies slightly; usually the better the quality the higher the gravity. Its taste is sweet. Samples having an acrid taste are met with, but generally they are not reliable.

Dragon's blood is readily soluble in alcohol, benzol, chloroform, carbon bisulphide, petroleum spirit, shale spirit, glacial acetic acid, caustic soda, ammonia and other solvents, giving crimson solutions. Ether does not dissolve it readily, while it is almost insoluble in turpentine. It melts at about 120° C. (248 F.), and softens at a lower temperature. For ordinary commercial purposes dragon's blood is sold in a powdered form; it is largely used for colouring varnishes of all kinds, imparting to them a deep red colour.

Several other varieties of dragon's blood come into commerce. Socotran dragon's blood is the product of *Dracaena* *ombet* and of *Dracaena schizantha*. The resin is obtained from these trees by making incisions and collecting the resin which exudes from the cuts. This variety is usually in the form of tears or drops, and finds its way into the London market through Zanzibar and Bombay. A variety of dragon's blood is obtained from the celebrated dragon tree of Teneriffe and adjacent islands, the *Dracaena draco*. Mexican dragon's blood is obtained from the *Croton draco*. But little of these two latter varieties comes into this country.

**DRIERS** form a group of bodies, mostly of a metallic character, which are added to linseed and other painting oils, and to paints and varnishes, for the purpose of making them dry quicker. The most commonly used driers are litharge, red lead, lead acetate, lead borate, lead resinate, manganese oxide, manganese sulphate, manganese borate, manganese oxalate, manganese linoleate,. manganese resinate, ferrous sulphate, zinc oxide, and zinc sulphate. The properties of driers have been discussed in the author's *Manual of Painters' Colours, Oils and Varnishes*, to which the reader is referred See also under *Linseed Oil*.

**DROP BLACK,** the name given to Frankfort black and to other blacks, which are made up into conical lumps with the aid of a little adhesive matter. See *Frankfort Black*.

**DROP LAKE,** a crimson lake made up into what is known as the "drop" form.

**DRYING OILS** form a group of oils, derived from vegetable and animal sources, which have the property of drying into a hard mass when exposed in thin layers to the atmosphere. Linseed oil is the typical member of this series of oils. The following is a list of the most important drying oils:—

Linseed oil.
Weld seed oil.
Tobacco seed oil.
Hempseed oil.
Walnut oil.
Poppy seed oil.
Scotch fir seed oil.
Menhaden oil.

Each of these will be found described in its proper place.

The fatty oils, as they are called, are a group of bodies derived from both animal and vegetable sources. Some are fluid at ordinary temperatures, others are solids of varying consistency; but whether a particular fatty body shall appear as a liquid oil or a solid fat is simply a question of temperature. At a sufficiently high temperature all these bodies are liquid; at a sufficiently low one all would be solid bodies. Butter in England is a fat; in India it is an oil. Palm oil in Africa is an oil; in England a fat. Olive oil in England is ranked as an oil; in Greenland it would be classed as a fat. The oils generally are bodies which are insoluble in water, only slightly so in alcohol, freely soluble in ether, petroleum spirit, carbon bisulphide, turpentine and other similar solvents.

The oils and fats belong chemically to that group of chemical compounds known as salts, which may be defined as compounds containing two chemical radicles, one of which is of acid origin, the other of basic origin.

In the case of oils and fats, the basic radicle is always that known as *glyceryl*, $C_3H_5$, which, when combined with *hydroxyl*, HO, forms the well-known substance *glycerine*, $C_3H_5(OH)_3$; hence oils and fats are frequently named *glycerides*, because when they are subjected to saponification they always yield glycerine.

In oils and fats the glyceryl is present in combination with one or more acid radicles. It may here be pointed out that while there is only one base present in any particular oil or fat, yet there may be several fatty acids. Some of the more common of the fatty bodies (such as tallow, olive oil) rarely contain more than two; others again (butter, cocoanut oil, palm nut oil) contain six or more different acids.

When an oil or fat is boiled with a solution of either caustic potash or caustic soda, it undergoes decomposition. The alkali combines with the fatty acid or acids to form soap, while glycerine is liberated. If the soap be collected, and an acid like hydrochloric acid or sulphuric acid be added, it is decomposed. The fatty acid or acids are liberated and may be collected. In appearance the fatty acids resemble the oils themselves; they differ, however, in being soluble in alcohol, while the oils are not. Necessarily they are of an acid character, and combine at once with either caustic soda or caustic potash, or with ammonia to form alkaline soaps, which are soluble in hot or cold water. These fatty acids will also combine more or less readily with lime, lead oxide, and other metallic oxides, but the bodies then formed are insoluble in water; they are also termed soaps. One or two are of some service.

Glycerine will be found described under *Glycerine.*

The fatty acids at present known may be divided into five groups, as follows:—

### 1. Stearic Series of Fat Acids.

General formula $C_nH_{2n}O_2$.

| Name. | Formula. |
|---|---|
| Formic | $HCHO_2$ |
| Acetic | $HC_2H_3O_2$ |
| Butyric | $HC_4H_7O_2$ |
| Caproic | $HC_6H_{11}O_2$ |
| Œnanthylic | $HC_7H_{13}O_2$ |
| Caprylic | $HC_8H_{15}O_2$ |
| Pelargonic | $HC_9H_{13}O_2$ |
| Capric | $HC_{10}H_{19}O_2$ |
| Cocinic | $HC_{11}H_{21}O_2$ |

| Name. | Formula. |
|---|---|
| Lauric | $HC_{12}H_{23}O_2$ |
| Myristic | $HC_{14}H_{27}O_2$ |
| Isoacetic | $HC_{15}H_{29}O_2$ |
| Palmitic | $HC_{16}H_{31}O_2$ |
| Daturic | $HC_{17}H_{33}O_2$ |
| Stearic | $HC_{18}H_{35}O_2$ |
| Arachidic | $HC_{20}H_{39}O_2$ |
| Behenic | $HC_{22}H_{41}O_2$ |
| Lignoceric | $HC_{24}H_{47}O_2$ |
| Carnaubic | $HC_{24}H_{47}O_2$ |
| Hyaenic | $HC_{25}H_{49}O_2$ |
| Cerotic | $HC_{27}H_{53}O_2$ |
| Melissic | $HC_{30}H_{59}O_2$ |

Of these acids, formic and acetic acids are liquids, they have a powerful acrid odour, are soluble in water and can be distilled without any change. The next few members are also liquid bodies, of rather higher boiling points than the two just named. Some have an odour recalling that of rancid fat, and they have a more or less fatty appearance; although soluble in water, their solubility is not great. They can be distilled without change along with water. These acids are present in butter, cocoanut oil, palm nut oil in notable amounts, and are called the *soluble fat acids.*

Capric acid and all others below that in the table given above are solid acids of varying consistence, some being crystalline and fatty in appearance; they are all insoluble in water and hence are known as the *insoluble fatty acids.* They cannot as a rule be distilled without undergoing decomposition.

The fat acids of the stearic series are soluble in alcohol, ether, turpentine, petroleum spirit and similar solvents. They are monobasic acids, combining with one equivalent of potassium hydroxide (caustic potash) or sodium hydroxide (caustic soda) to form the bodies known as *soaps*, which are more or less soluble in water ; those formed from the lower fat acids being freely soluble, while those from the higher ones are more difficultly soluble, the solubility decreasing with the complexity of the acid. These acids have no power of combination with bromine or iodine.

2. **Oleic Series of Fat Acids.**

| Name. | Formula. |
|---|---|
| Acrylic | $HC_3H_3O_2$ |
| Crotonic | $HC_4H_5O_2$ |
| Angelic | $HC_5H_7O_2$ |
| Pyroterebric | $HC_6H_9O_2$ |
| Damaluric | $HC_7H_{11}O_2$ |
| Meringic<br>Cimicic | $HC_{15}H_{27}O_2$ |
| Physotoleic<br>Hypogaeic<br>Gaidic | $HC_{16}H_{31}O_2$ |
| Oleic<br>Elaidic | $HC_{18}H_{33}O_2$ |
| Doeglic | $HC_{19}H_{35}O_2$ |
| Erucic | $HC_{22}H_{42}O_2$ |

Of these acids, oleic is by far the most characteristic of all oils ; when combined with glyceryl it forms olein which is generally found present in all fluid oils. The lower members are soluble in water and can be distilled without decomposition ; the higher members are insoluble in water and cannot be distilled without decomposition. They will combine directly with bromine or iodine, taking up those elements in the proportion of two atoms of the halogen for each molecule of acid. Another property they possess is that of being readily converted into isomeric bodies ; thus oleic acid is converted by the action of nitrous acid, or of a solution of nitrate of mercury, containing nitrous acid in solution, into elaidic acid ; hypogaeic acid into gaidic acid ; erucic acid into brassidic acid.

### 3. Linolic Series of Fat Acids.

| Name. | Formula. |
|---|---|
| Elaeomargaric . . | $HC_{17}H_{29}O_2$ |
| Tariric . . . | $HC_{18}H_{31}O_2$ |
| Linolic . . . | $HC_{18}H_{31}O_2$ |

These acids are found principally in drying oils ; they are liquid acids, insoluble in water ; they combine with bromine and iodine, taking up four atoms of those elements for each molecule of acid.

### 4. Linolenic Series of Fat Acids.

| Name. | Formula. |
|---|---|
| Linolenic acid . . | $HC_{18}H_{29}O_2$ |
| Isolinolenic . . | $HC_{18}H_{29}O_2$ |
| Jecoric . . . | $HC_{18}H_{29}O_2$ |

These acids are also characteristic of drying oils ; they will combine with bromine or iodine in the proportion of 6 atoms for each molecule of acid.

### 5. Ricinoleic Series of Fat Acids.

| Name. | Formula. |
|---|---|
| Ricinoleic<br>Isoricinoleic<br>Rapic acid . . | $HC_{18}H_{33}O_3$ |

These acids are found in castor and rape oils; they are hydroxlated acids allied to the oleic series. Their principal peculiarity is that they are insoluble in petroleum ether ; their glycerides are soluble in alcohol and glacial acetic acid ; and the soaps made from them are very soluble in water. They absorb bromine or iodine in the proportion of 2 atoms for each molecule of acid.

The oils are obtained from vegetable seeds and fruits (usually by pressing) and from animal fats by various methods depending on the character of the raw material.

As stated above, all the oils when boiled with a solution of caustic soda or of caustic potash undergo saponification ;

there is formed by the union of the alkali with the aci constituent of the oil a soap, while the base of the oil i liberated in the form of glycerine. The reaction which take place is shown in the following equation:—

$$\begin{array}{cccc} C_3H_5\left\{\begin{array}{l}C_{18}H_{31}O_2\\ C_{18}H_{31}O_2\\ C_{18}H_{31}O_2\end{array}\right. & +\ 3KOH & =\ 3KC_{18}H_{31}O_2 & +\ C_3H_5\left\{\begin{array}{l}OH\\ OH\\ OH\end{array}\right. \\ \text{Linolin} & \text{Caustic Potash} & \text{Potassium linolate (soft soap)} & \text{Glycerine} \end{array}$$

When the oils and fats are subjected to the combined action of heat and steam, they take up the elements of water (or undergo what is called *hydrolysis*) and form glycerine and free fatty acids, as shown in the following equation:—

$$\begin{array}{cccc} C_3H_5\left\{\begin{array}{l}C_{18}H_{35}O_2\\ C_{18}H_{35}O_2\\ C_{18}H_{35}O_2\end{array}\right. & +\ 3H_2O & =\ 3HC_{18}H_{35}O_2 & +\ C_3H_5\left\{\begin{array}{l}OH\\ OH\\ OH\end{array}\right. \\ \text{Stearin} & & \text{Stearic acid} & \text{Glycerine} \end{array}$$

See Andés' *Drying Oils, Boiled Oil, and Solid and Liquid Driers.*

**DUTCH PINK.**—This pigment is a yellow lake prepared from fustic or Persian berries by precipitation with alum and whiting. It is used chiefly in paper staining, but its use is gradually becoming obsolete. Dutch pinks are rather fugitive, but have the merit of not losing tint when exposed to gaslight. English and Italian pinks are other names for them.

## E.

**ELEMI.**—See *Gum Elemi.*

**EMERALD GREEN.**—This pigment is a compound of acetic acid, arsenious acid and copper, and is the aceto-arsenite of copper. It is prepared by precipitating a solution of copper sulphate and acetate with a solution of sodium arsenite by acting on Scheele's green with acetic acid, by mixing Scheele's green with verdigris. Its composition is shown in the following analysis:—

| | Per Cent. |
|---|---|
| Copper oxide, $CuO$ . . . . . | 32·55 |
| Arsenious oxide, $As_2O_3$ . . . . | 57·51 |
| Acetic anhydride, $O2C_2H_3O_2$ . . | 6·63 |
| Sulphur trioxide, $SO_3$ . . . | 1·67 |
| Water, $H_2O$ . . . . . | 0·90 |

Emerald green has the following properties: It has a pale but bright bluish-green colour, of a hue different from that of any other pigment. It is opaque, and hence possesses good body and covering powers. It mixes well with either oil or water, and hence can be used either for oil or water-colour painting. It is not permanent under exposure to light and air, although it has fairly good resistant powers, especially in dry places. It is used in large quantities as an insecticide, especially in America, where it is chiefly known under the name of Paris green. Its use as a pigment in painting and for printing paperhangings has greatly decreased of late years on account of its extremely poisonous properties, its place being taken by greens prepared from coal-tar colours. Emerald green will mix with most other pigments, the only exceptions are those containing sulphur, such as ultramarine and cadmium yellow, as the sulphur in these has a tendency to form the black copper sulphide, the production of which would have a tendency to lead to the discolouration of the pigment.

Emerald green is soluble in acids to pale blue solutions. On adding ammonia to these there is first obtained a light blue precipitate of copper hydroxide; but this, on the addition of excess of ammonia, dissolves with the formation of a deep blue solution. It is soluble in ammonia and solutions of caustic soda and caustic potash. On boiling the latter solutions a red precipitate of cupreous oxide is obtained.

[illegible]

[illegible] adding a little barium [illegible] faintest precipitate [illegible] be obtained [illegible] gas through the [illegible] sulphides of arsenic [illegible] this precipitate [illegible] ammonium [illegible] formed.

Emerald green is also known as Schweinfurth green from the name of the town in which it was first made.

**ENGLISH PINK,** a name given to yellow pigments prepared from Persian berries; they are similar to Dutch pinks.

**ENGLISH WHITE** is a name given to a good grade of *Whiting*, which see.

**EOSINE.**—Eosine is a coal-tar dye derived from the substance fluorescein, which has the formula $C_{20}H_{10}O_5$; this product is characterised by its solutions having a strong, green fluorescence or bloom. There are several varieties of eosines which are prepared from fluorescein by the action of bromine, iodine or nitric acid. The following are the principal eosines met with in commerce:—

**Eosine A., Eosine J., Eosine GG.**—Under these names, and possibly others, is sold the potassium salt of tetra-bromfluorescein, $C_{20}H_6Br_4O_5K_2$; this dyes bright reds of a yellower tone than other eosines.

**Eosine BN. Safrosine.**—Under this name is sold the potassium salt of dibroma-dinitro-fluorescein, $C_{20}H_6Br_2O_5(NO_2)_2K_2$, which dyes much bluer shades than the last-named product.

**Erythrosine, Eosine J.,** is the potassium salt of tetraiodofluorescein, $C_{20}H_6I_4O_5K_2$, which dyes bluish reds.

**Phloxine, Erythrosine B. and Phloxine T.** are bromo-chloro-fluoresceins, and dye very blue shades of red.

**Rose Bengale** is the potassium salt of tetraiodo-dichlorofluorescein. It dyes the bluest shades of all the eosine group of dyestuffs.

Two different substances are sold by various makers as eosine J.

The eosines are characterised by dyeing shades of red of great brilliance, but, unfortunately, they are very fugitive when exposed to air and light.

Eosines, especially the yellower brands, are used in the manufacture of vermilionettes, royal reds, imperial reds, signal red, and other red pigments of a bright scarlet colour, their use for this purpose depending on the fact that they give with lead and alumina insoluble colour-lakes. Eosine lake-pigments are always mixed with such bodies as white lead, barium sulphate, lead sulphate. See the author's *Manual of Painters' Colours*; and the articles in this work on *Vermilionette* and *Royal Reds*.

**ETHER.**—Sometimes called, to distinguish it from other ethers, sulphuric ether. It is an extremely light, volatile liquid, having a specific gravity of 0·735, has a pleasant and characteristic odour, boils at 40·5° C. (105° F.), and leaves no residue on evaporation. It mixes readily with alcohol, but not with water. It is a powerful solvent of oils, fats, resins and similar substances. It has the composition shown in the formula $(C_2H_5)_2O$. The commercial product usually contains 92 to 94 per cent. of ether.

Ether is prepared from alcohol by heating with sulphuric acid; methylated spirit may be used, in which case the product is known as "methylated ether".

**ETHYL ALCOHOL.**—See *Alcohol.*

## F.

**FATTY ACIDS.**—The name given to a number of acid bodies found in the animal and vegetable fats and oils and in waxes. Their names have already been given under *Drying Oils.*

**FELSPAR,** one of the minerals found in granite, is essentially a double silicate of alumina and potassium, or soda lime. The commonest is the potash felspar. The principal varieties of felspar are orthoclase, the potash felspar; albite, the soda felspar; oligoclase, the soda-lime felspar; anorthite, the lime felspar; and labradorite, the lime-soda felspar. Orthoclase, the potash felspar, has the percentage composition: silica, 64·6; alumina, 18·5; potash, 16·9. Occasionally some specimens contain a little sodium in place of the potash. The formula is $Al_2O_3 3SiO_2$, $K_2OSIO_2$, $2SiO_2$. The specific gravity is 2·6. It is hard and insoluble in all acids except hydrofluoric acid. It is slightly opaque, generally of a pink colour, but white, grey or brown felspars are met with. Albite, the soda felspar, has a similar composition to orthoclase, but has sodium in place of potassium. In hardness and specific gravity it is the same. Its crystalline form is somewhat different from that of orthoclase. The other felspars are not so important.

When exposed to the atmosphere the felspars become more or less decomposed; the alkali they contain is washed away by the combined action of the water and carbonic acid of the air, while the silica and alumina remain behind and form a hydrated silicate of alumina, which is known as kaolin, or *China Clay*, which see.

**FERRIC OXIDE,** the most important of the oxides of iron, has a composition corresponding to the formula, $Fe_2O_3$. It occurs naturally in a great variety of forms, as the minerals known as hæmatite, limonite, specular iron ore, etc. It is also found in other rocks and minerals. It is the colouring agent in ochres, siennas, umbers, and other natural earth pigments of a yellow to brown colour. It forms the basis of many red pigments, rouge, colcothar, Indian red, red oxide, etc. It is soluble in acids, when it forms the ferric salts, many of which are of some service. When ammonia or caustic soda is added to a solution of a ferric salt the hydroxide, $Fe_2H_6O_6$, is thrown down as a flocculent foxy brown precipitate, which on ignition loses water, and becomes transformed into the oxide. See also *Colcothar, Rouge, Indian Red, Iron Oxides.*

**FERROUS SULPHATE.**—This salt of iron is one of great importance, and is manufactured on a large scale by various processes, chiefly by the oxidation of pyrites by exposure to the air. It forms very fine, pale green crystals, having the composition shown in the formula, $FeSO_4, 6H_2O$. It is known commercially as copperas, and two kinds are distinguished, *green copperas*, the name for the freshly-prepared crystals; and *brown copperas* that for the green crystals which have been exposed to the air for a short time, and have, therefore, become incrusted with a slight brown coating of the oxide of iron. Kept in a dry place ferrous sulphate is fairly stable, but if exposed to moisture and air it soon becomes oxidised. It is soluble in water without much difficulty; the solution, is, however, not stable, as a deposit of ferric oxide forms, while ferric sulphate remains in solution. Ferrous sulphate is employed in the preparation of Prussian blue, rouge, red oxide, Indian red, and fuming sulphuric acid, for dyeing and other purposes. For all these purposes it should be free from any insoluble matter, as also from lime and ferric oxide. The following are analyses of commercial samples of copperas:—

| | Green Copperas. Per Cent. | Brown Copperas. Per Cent. |
|---|---|---|
| Iron . . . . . . | 18·68 | 17·22 |
| Alumina . . . . . | 1·71 | 2·00 |
| Sulphuric acid . . . . | 37·21 | 36·63 |
| Water of crystallisation . | 42·40 | 44·15 |

**FIR SEED OIL.**—This oil is obtained from the seeds of several species of *Coniferæ*, *Pinus sylvestris*, *Pinus picea* etc. It is a limpid oil of a pale yellow colour and a sweeti taste. Its specific gravity at 60° F. varies from 0·925 to 0·931, varying with the species of pine or fir, from which it is derived. It does not solidify until the temperature rises to 27° or 30° C. It requires 19 per cent. of caustic potash to saponify it, and absorbs 118 to 119 per cent. of iodine. It dries fairly easy, although not quite so well as linseed oil; it is, therefore, used in making paints and varnishes.

**FLINT.**—This substance is found in the form of round pieces of irregular shape and size in the chalk. The pieces are covered with a white crust, but the interior is of a brown or black colour. It breaks with a smooth fracture. It is exceedingly hard and will scratch glass. It is almost pure silica in its composition. It is largely used in the pottery industry for making various kinds of earthenware and porcelain goods.

**FLORENTINE LAKE.**—A red lake pigment prepared from cochineal by precipitation with alumina. In properties it resembles *Crimson Lake*, which see.

**FOUSEL OIL.**—This is the name given to the crude amyl alcohol, obtained in the manufacture of whisky from potatoes. See *Amyl Alcohol*.

**FRANKFORT BLACK.**—This black pigment is prepared from the twigs of trees, cork, etc., by heating them in a closed vessel, then washing with water and drying. The dried black is mixed with a little glue water and made up into large pear-shaped masses, or drops as they are called; hence this black is also known as drop black. It is a black pigment of fine texture, varying in hue from a bluish-black to a reddish-black, this difference in hue depending upon the character of the materials from which it is made, vegetable matters tending to give a bluish-black, animal matters a reddish-black. The colour of Frankfort black is due to carbon, of which there is usually from 65 to 70 per cent. present in good samples. The rest of the black consists of moisture amounting to 2 to 3 per cent., and mineral matter. This, if the black is prepared from animal matters, will contain phosphate of lime; if from vegetable matters it will consist chiefly of alkaline salts, and will not be present in as large a proportion.

Frankfort black is largely employed in making printing inks, although it is being superseded by the vegetable blacks and carbon blacks, which have been introduced of late years.

**FRITS** are a class of half-vitrified bodies used in the manufacture of pottery, and made from flint, china clay, bone ash, etc. Their composition varies with the character of the pottery of which they are to form a part.

## G.

**GAHN'S ULTRAMARINE,** a name given to *Cobalt Blue*, which see.

**GAMBOGE.**—This is a gum-resin of a bright yellow colour obtained from *Garcinia morella*, a tree which grows very extensively in Siam, from which gamboge is exported in large quantities. The resin is obtained from the trees by making incisions and collecting the resin which exudes. It is then melted and poured into the hollows of bamboo canes, whereby it is moulded into long cylindrical pieces, in which form it usually makes its appearance on the English market. It is rather brittle, and is easily converted into a yellow powder. On this account the pieces of gamboge are often covered with a When broken it exhibits a conchoidal fractur with a vitreous lustre. It is translucent in mass, but when viewed in thin slices it is transparent. It is partially soluble in water, giving a yellow-coloured solution, which is slightly turbid. The solution has a slight taste when first taken, but develops an acrid after-taste. The resin possesses purgative properties, on which account it is often employed in medicine.

The following analysis of gamboge made by the author shows the composition and constituents of gamboge:—

| | Per Cent. |
|---|---|
| Moisture | 2·50 |
| Mineral matter | 1·05 |
| Resin, soluble in ether | 66·05 |
| Wax, soluble in alcohol | 4·31 |
| Gum | 26·03 |

To the resin which is found in gamboge, and to which its colouring power is due, the name of gambogic acid has been given, and the formula $C_{30}H_{35}O_6$. It can be obtained from gamboge by treatment with ether. On evaporating off the solvent it is left behind as a transparent, vitreous and brittle mass breaking with a conchoidal fracture. When in mass it has a reddish-orange colour, and forms a yellow powder. It has no odour or taste, and appears to be destitute of purgative properties. The resin is readily soluble in ether, alcohol and chloroform; petroleum spirit has but a slight solvent action on it. Alkaline solutions readily dissolve it, forming dark-coloured solutions; it dissolves also in solutions of the alkaline carbonates with evolution of carbonic acid, thus showing that it possesses acid properties. On acidifying the alkaline solutions the resin is thrown down in the form of flakes. This resin forms the largest proportion of gamboge.

The wax of gamboge, which is insoluble in ether but soluble in alcohol, is a soft brownish substance, melting readily at a low temperature. It has a bitter taste, which is very persistent, and appears to have purgative properties to a slight extent. It dissolves in a solution of caustic soda with a brown colour, but it is reprecipitated on addition of acids.

The gum of gamboge forms a brownish mass, which is somewhat transparent. Its taste is sweet. Its adhesive properties are but slight. It is soluble in water, giving an opalescent solution, which becomes clear on the addition of acids. From the aqueous solution the gum is not precipitated on adding lead acetate, ferric chloride, mercuric chloride, borax or alcohol. It seems to be a glucoside, forming a sugar on being hydrolysed.

Gamboge is employed as a pigment in water-colour painting and as a colouring matter for spirit varnishes.

**GASOLINE** is the name given to the lightest product derived from petroleum imported into this country. The crude petroleum, as it comes from the wells of America, is sent into the refinery and there distilled in large stills (capable of holding from 25,000 to 50,000 gallons) with fire, or with fire and steam The first light volatile products are collected until they have a specific gravity of 0·729 ; they constitute what is known as *crude naphtha.*

This is subjected to a process of refining by treatment with sulphuric acid and caustic soda in succession and then distilled fractionally, when it is usually separated into the following fractions :—

| | Specific Gravity. |
|---|---|
| Rhigoline or cymogene (used for surgical purposes) . . . . . . | 0·636 |
| Gasoline (used for carburetting gas) . | 0·642 |
| Gas naphtha (used for lamps) . . | 0·678 |
| Benzoline . . . . . . . | 0·690 to 0·707 |
| Benzine or naphtha (for varnish making) | 0·730 |

Gasoline is a water-white and very volatile liquid used for dissolving resins, carburetting gas, etc.

Its specific gravity rarely exceeds 0·650, but is usually less. It ought to distil almost entirely at the boiling point of water. Gasoline has a complex chemical composition, consisting chiefly of the lower members, butane, pentane, hexane, butene, pentene, hexene, of the paraffin and olefine series of hydrocarbons. See *Paraffins* and *Olefines*.

**GELATINE.**—This is the name given to the nitrogenous organic substance which forms a great proportion of the animal tissues of bones, skin, etc. This body appears to vary slightly in composition according to the portion of the body from which it is obtained. The following analysis shows its average composition :—

| | Per Cent. |
|---|---|
| Carbon . . . . . | 50·0 |
| Hydrogen . . . . | 6·6 |
| Oxygen . . . . | 25·1 |
| Nitrogen . . . . | 18·3 |

It possesses the following properties: If dry and placed in cold water it absorbs it and swells up forming a jelly-like mass, but is insoluble in cold water. In boiling water it dissolves, forming a viscid solution which possesses strong adhesive properties. On cooling the mass sets into a jelly. This gelatinising action of gelatine is very strong, from 1 to 2 per cent. of gelatine dissolved in hot water being sufficient to cause the mass to set into a jelly on becoming cold. Gelatine is precipitated from its solutions in water by tannic acid, mercuric chloride and alcohol. Acetate of lead and potassium ferrocyanide do not precipitate it.

Gelatine is soluble in strong acetic acid. Such a solution forms the basis for the many cements which are sold for glass, etc., its adhesive powers being very strong. Mineral acids, such as nitric and hydrochloric, also dissolve gelatine. Such solutions have also been used as cements. Gelatine is also soluble in alkaline solutions.

When gelatine solutions, whether in water, acids or alkalies, are boiled, the gelatine undergoes hydrolysis and loses its power of gelatinising, and if the boiling be prolonged there is found among the products leucine and glycocoll. No tyrosin is formed, a feature which distinguishes gelatine from other proteid bodies.

Chromates, under the influence of light, have the property of rendering the gelatine insoluble in water. This property is taken advantage of in photography to a very large extent.

Gelatine forms the basis of glue (see *Glue*), while it is prepared in a fairly pure condition and sold as gelatine for a variety of purposes. The method of making these will be briefly pointed out in connection with glue. Isinglass, which is largely used for making jellies, is a fairly pure form of gelatine.

Good gelatine should be quite clear and transparent when in thin sheets. It should not yield more than 1½ per cent. of ash, although some samples contain as much as 2 per cent., which is the maximum allowable. Samples which contain more may be put down as adulterated. When soaked in cold water gelatine ought to absorb as much as will suffice to dissolve the swollen gelatine when heated to 80° or 90° F. The amount of gelatine may be approximately ascertained by dissolving the sample in water and adding alcohol to precipitate the gelatine, which is collected on a filter and, after drying, weighed. See Lambert's *Bone Products and Manures*.

**GLAUBER'S SALT.**—The crystallised sodium sulphate, $Na_2SO_4 10H_2O$, is known under the name of Glauber's salt.

It is largely employed in dyeing, in glass making, and for other purposes. See *Sodium Sulphate.*

**GLAZES** (in pottery manufacture) are those materials which are employed to give the glaze on the exterior of the pottery. For this purpose there is employed salt, lead acetate, borax, etc. Sometimes a metallic oxide, like the oxides of cobalt, copper, iron, etc., is added to the glaze for the purpose of colouring it. It is impossible here to give any details for the preparation of these glazes; for this reference should be made to books dealing with pottery manufacture, such as the *Manual of Practical Potting* and *Ceramic Technology*, sent out from the offices of the *Pottery Gazette.*

**GLUE.**—This valuable product consists essentially of gelatine, and is prepared from a variety of animal products. It varies very much in purity and quality, from the almost colourless varieties of gelatine and fish glues, which are nearly pure gelatine, to the dark-coloured, thick, long Scotch glues as they are called. Glues are made by digesting bones and other animal tissues at a low temperature (best in a vacuum apparatus), then clarifying the liquor from any insoluble portions, setting this in moulds to cool, and, when cold, cutting it into thin slices and exposing these on netting until dry, when the glue is ready for use. The palest glues are made from the best materials, and the hot liquors are generally clarified or bleached by treatment with sulphurous acid, or filtering through animal charcoal before cooling and drying. The darkest glues are made from bones, etc., and are not treated before drying. The chemical properties of gelatine have already been given under *Gelatine*, and glue necessarily possesses the same properties.

Good glue ordinarily contains from 12 to 18 per cent. of water, and from 1½ to as much as 5 per cent. of mineral matter. The examination of glue for quality may be conducted in the following manner:—

*Moisture.*—Two or three grammes of the glue are broken into small pieces and kept in a hot oven at from 105° to 115° C. until the weight is constant. The loss of weight represents the amount of water contained in the glue.

*Mineral Matter.*—The glue from the last test is transferred to a porcelain (or, better, platinum) crucible and heated to bright redness until the whole of the carbonaceous matter has been burnt off. The residue is weighed. It may then be subjected to a qualitative analysis, if it be desired to ascertain something of the source of the glue. If the glue has been made from bones the ash or mineral matter can be fused over the Bunsen burner. It will contain calcium phosphate and yield little or nothing to water. In any case an aqueous solution will be neutral. Glue made from leather shavings or from skins gives a residue of mineral matter which is not fusible, contains little, if any, phosphoric acid, and is alkaline, owing to the presence of quicklime.

*Acidity.*—Glues are sometimes acid in reaction, due either to a natural acidity of the materials from which they are made, or to the use of sulphurous acid for bleaching the glue. The proportion of acidity may be ascertained by taking 10 grammes of the glue and dissolving them in 100 c.c. of hot water; then, if the glue be not too dark, a few drops of a solution of phenol-phthalein are added and the solution titrated with a standard solution of caustic soda until a permanent pink colouration is obtained. The colour of the solutions of dark glues will not permit of this method of examination. In this case 25 to 30 grammes of the glue are dissolved in 100 c.c. of water and the solution distilled until one-half the volume has come over. The distillate is then titrated with standard caustic soda, using phenol-phthalein as an indicator. For the sake of comparison the amount of acidity may be calculated as equal to sulphuric acid.

*Absorbing Power.*—The amount of water which glues are capable of absorbing is a fair test of their quality. A piece of glue of known weight is placed in a saucer of water and allowed to stand for twenty-four hours, after which the jelly-like mass that is formed is removed and weighed. The proportion of water absorbed can then be calculated.

*Consistency of Solution and Jelly.*—Two to five grammes of the glue are placed in 166 c.c. of water and allowed to stand over night. The next day the mixture is heated nearly to the boiling point until the glue is completely dissolved, when it is placed on one side and allowed to set into a jelly, the consistency of which can be compared with a similar jelly made from a sample of good glue. Then the jelly may be heated so as to dissolve the glue and the consistency of the liquor compared with that prepared from a standard sample.

For further information on glue see Dr. S. Rideal's book on *Glue and Glue Testing.*

**GLYCERINE.**—This substance is found as the basic constituent of all animal and vegetable oils and fats, from which bodies it is commonly obtained on the large scale. It is also formed in small quantity during the fermentation of sugar into alcohol. When an oil is boiled with caustic soda or caustic potash the acid of the oil (see *Drying Oils*) combines with the alkali to form a soap, while the glyceryl radicle combining with the hydroxyl of the alkali forms glycerine or, as chemists now call it, glycerol. The glycerine (which is the name that, as being most familiar, will be given to it here) is found in the aqueous liquor which is obtained (the spent lye of the soap maker) when the soap is thrown out of solution by the addition of salt. From these spent lyes the glycerine is recovered by a process which consists in neutralising the lye with hydrochloric acid, evaporating the liquor down, separating the salt which crystallises out, decolourising the liquor, if required, by means of animal charcoal, then distilling the glycerine in a vacuum distilling apparatus. In place of decomposing the oils or fats with alkali they are often decomposed by means of a small proportion of lime under great pressure in an autoclave, or by distilling them with superheated steam.

Glycerine is a water-white, very viscid liquid, having a specific gravity of 1·270 at 60° F. when pure. It is a powerful absorbent of water, so that it cannot be kept exposed to the air. When heated it is slightly volatile, not without some decomposition. It is incombustible under ordinary circumstances, and will only burn when heated and with excess of air. The flame is luminous, but very smoky. It is soluble in water, with which it will mix in all proportions, the specific gravity of the mixture varying with the proportion of water to glycerine, so much so that given a simple mixture of glycerine and water the proportion of glycerine may be ascertained with a fair degree of approximation to the truth by ascertaining the specific gravity.

Glycerine is insoluble in ether, carbon bisulphide, chloroform, petroleum spirit, benzene.

It possesses very powerful solvent properties, dissolving such bodies as caustic soda, lead oxide, sodium carbonate, potassium sulphate, copper sulphate, quinine, etc.

When glycerine is heated with strong sulphuric acid or other dehydrating agent, it is decomposed and acrolein, distinguished by its strong odour and irritating action on the eyes, is obtained. When boiled with an aqueous solution of potassium permanganate, made alkaline with caustic soda, it is oxidised to oxalic acid, the reaction taking place in quantitative proportions, so that it may be taken advantage of to determine the proportion of glycerine in soap leys, etc.

The following table gives the specific gravity of glycerine solution at 15° C. (60° F.) :—

| Specific Gravity. | Per Cent. Glycerine. | Specific Gravity. | Per Cent. Glycerine. | Specific Gravity. | Per Cent. Glycerine. |
|---|---|---|---|---|---|
| 1·0024 | 1 | 1·0885 | 35 | 1·1799 | 68 |
| 1·0048 | 2 | 1·0912 | 36 | 1·1821 | 69 |
| 1·0072 | 3 | 1·0939 | 37 | 1·1855 | 70 |
| 1·0096 | 4 | 1·0966 | 38 | 1·1882 | 71 |
| 1·0120 | 5 | 1·0993 | 39 | 1·1909 | 72 |
| 1·0144 | 6 | 1·1020 | 40 | 1·1936 | 73 |
| 1·0168 | 7 | 1·1047 | 41 | 1·1963 | 74 |
| 1·0192 | 8 | 1·1074 | 42 | 1·1990 | 75 |
| 1·0216 | 9 | 1·1101 | 43 | 1·2017 | 76 |
| 1·0240 | 10 | 1·1128 | 44 | 1·2044 | 77 |
| 1·0265 | 11 | 1·1155 | 45 | 1·2071 | 78 |
| 1·0290 | 12 | 1·1182 | 46 | 1·2098 | 79 |
| 1·0315 | 13 | 1·1209 | 47 | 1·2125 | 80 |
| 1·0340 | 14 | 1·1236 | 48 | 1·2152 | 81 |
| 1·0365 | 15 | 1·1263 | 49 | 1·2179 | 82 |
| 1·0390 | 16 | 1·1290 | 50 | 1·2206 | 83 |
| 1·0415 | 17 | 1·1318 | 51 | 1·2233 | 84 |
| 1·0440 | 18 | 1·1346 | 52 | 1·2260 | 85 |
| 1·0465 | 19 | 1·1374 | 53 | 1·2287 | 86 |
| 1·0490 | 20 | 1·1402 | 54 | 1·2314 | 87 |
| 1·0516 | 21 | 1·1430 | 55 | 1·2341 | 88 |
| 1·0542 | 22 | 1·1458 | 56 | 1·2368 | 89 |
| 1·0568 | 23 | 1·1486 | 57 | 1·2395 | 90 |
| 1·0594 | 24 | 1·1514 | 58 | 1·2421 | 91 |
| 1·0620 | 25 | 1·1542 | 59 | 1·2447 | 92 |
| 1·0646 | 26 | 1·1570 | 60 | 1·2473 | 93 |
| 1·0672 | 27 | 1·1599 | 61 | 1·2499 | 94 |
| 1·0698 | 28 | 1·1628 | 62 | 1·2525 | 95 |
| 1·0724 | 29 | 1·1657 | 63 | 1·2550 | 96 |
| 1·0750 | 30 | 1·1686 | 64 | 1·2575 | 97 |
| 1·0777 | 31 | 1·1715 | 65 | 1·2600 | 98 |
| 1·0804 | 32 | 1·1743 | 66 | 1·2625 | 99 |
| 1·0831 | 33 | 1·1771 | 67 | 1·2650 | 100 |
| 1·0858 | 34 | | | | |

One very good test for glycerine is by means of borax, which is carried out in the following manner: A weak solution of borax is made, and to it is added a few drops of an alcoholic solution of phenol-phthalein, which will produce a rose colouration. The liquid which is to be tested for glycerine is made neutral, or even faintly alkaline to litmus, and is added to the borax solution until the rose colour is discharged, showing that the liquid has now an acid reaction. This is due to the fact that borax and glycerine combine together to form a compound having acid properties. On boiling the mixture the rose colour again appears, but on cooling again disappears.

**GOLD LIQUID.**—A preparation of precipitated gold and oil of tar, usually containing 12 per cent. of metallic gold, and employed in the gilding of porcelain and pottery. The oil of tar serves as a vehicle for the gold. On the articles being put into the kiln it burns off, leaving the gold behind. The precipitated gold is prepared in the following manner: Gold of the best quality is taken and placed in a mixture of 6 parts of hydrochloric acid and 2 parts of nitric acid; effervescence will occur and the gold will gradually dissolve, the action being promoted towards the end by a gentle heating. The acids should be allowed to take up as much gold as they will, so as to obtain as neutral a solution as possible. To the solution is added a little of the best grain tin. There will usually be required an amount of tin equal in weight to the gold dissolved. The tin will precipitate the gold in a very fine form. This is collected on a filter, carefully washed with water, dried and mixed with the oil of tar in the proper proportions. Sometimes a mixture of 2 parts of oil of amber and 4 parts of gurgun balsam is employed as a menstruum in place of the oil of tar. If the above mixture of gurgun and amber oil be too thick it may be thinned down by the addition of more oil of amber. Another method of precipitating the gold is to make a solution as before and to add a solution of ferrous sulphate made rather dilute. The gold will be thrown down. It is collected on a filter, well washed with water and dried, when it is ready for use.

**GREEN LAKE.**—Under this name used to be sold mixtures of Prussian blue with yellow lake. What is now sold as such consists of lakes precipitated from aniline or coal tar green dyes on a base of barytes or some other white pigment. Their preparation is fully described in the author's *Manual of Painters' Colours*.

**GREEN VERDITER.**—This pigment is the carbonate of copper prepared by precipitating solutions of copper salts with carbonate of soda or carbonate of potash. It has a pale green colour of no intensity, and but little covering or colouring powers. It has practically become obsolete as a pigment. Green verditer should be completely soluble in hydrochloric acid with effervescence. Sulphuretted hydrogen will throw down from this solution a black precipitate of copper sulphide. The filtrate from this precipitate should not give any further precipitate on the addition of ammonia, ammonium sulphide, or ammonium oxalate.

**GRIFFITH'S ZINC WHITE.**—This is a white pigment which contains, as its essential ingredient, zinc sulphide, which is present in combination with zinc oxide and barium sulphate. Its average composition is shown in the following analysis made by the author :—

| | Per Cent. |
|---|---|
| Hygroscopic water . . . . . | 1·36 |
| Combined water . . . . . | 3·71 |
| Zinc oxide, ZnO . . . . . | 9·18 |
| Zinc sulphide, ZnS . . . . . | 23·04 |
| Barium sulphate, $BaSO_4$ . . . . | 62·54 |

It closely resembles Orr's white, and is made by a similar process. It is a pigment of good body and intensity of colour works well in oil, and is permanent on exposure to the air. See *Orr's White* for further details.

**GUIGNET'S GREEN.**—This is the hydrated oxide of chromium prepared by heating bichromate of potash with boracic acid. The excess of boracic acid and the potassium salt which is formed is washed out with water, leaving the pigment behind as an insoluble green powder having a fairly bright colour. When dried and sold as a powder it is generally known as chrome green; but for certain purposes, *e.g.*, calico printing, it is sold in the form of a paste, containing from 40 to 50 per cent. of actual colour as Guignet's green. Guignet's green is a pigment of a fine green colour of a slightly yellow tone. It mixes well with either water or oil, and has good body or covering power and colouring power. It is unaffected by exposure to light and air and mixes well with all pigments without affecting them or being affected by them.

When properly made it is insoluble, or nearly so, in hydrochloric acid. The solubility, however, depends upon the degree of heat to which the oxide has been subjected—the stronger that is the more insoluble becomes the pigment. A good sample of Guignet's green should not impart a yellow colour to hydrochloric acid. A boiling solution of caustic soda should have no action on it. On dividing the solution into two portions and to one adding acetic acid no yellow precipitate (indicating the presence of chrome yellow) should be obtained; while, if to the other portion hydrochloric acid and ferric chloride be added, no blue precipitate (indicating the presence of Prussian blue) should form. It is with the pigments just named that Guignet's green is usually adulterated.

**GUMS.**—Under this generic term there comes into commerce a number of products of different properties and uses, the only resemblances between them being that they are all obtained from trees, have a similar appearance, and are pale in colour, glassy and more or less rounded. The gums may be divided into (1) gums proper, (2) gum resins, (3) resins, and (4) india-rubber gums.

The gums proper, which comprise gum arabic, gum tragacanth, gum ghatti, etc., are characterised by being either completely soluble in water, such as gum arabic or gum Senegal, or are altered by water, which causes them to swell somewhat; such are gum tragacanth and gum ghatti. The gum resins are those which, like gamboge, contain both a gummy matter and a resin. The resins are hard and brittle bodies, insoluble in water, and often nearly so in alcohol. They vary much in their properties, and are valuable products, especially for varnish making. The last class comprises india-rubber, gutta-percha, and gum balata, which have special characters, properties and uses.

The following gums and resins are those which are of most importance in the preparation of paints and varnishes: *Gum accroides*, *gum animi*, *gum arabic*, *gum benzoin*, gum *copal*, gum *dammar*, *gum elemi*, gum *kauri*, *gum mastic*, gum *sandarac*, *gum thus*, *gum tragacanth*, shellac and *rosin*. These are described under their names as italicised. For shellac see *Lac*.

**GUM ACCROIDES.**—This gum is also known as black bey gum, Xanthorrhea resin, etc. The gum, or rather resin, is obtained from several species of *Xanthorrhea* trees, which are natives of Australia. It has of late years been largely imported into this country for employment in varnish making. The resin exudes from the trees to a large amount during the hot season, and is also found imbedded in the stems from which this resin is obtained by crushing the wood and sifting the powdered resin from the woody tissue. The resin is obtained principally from the *Xanthorrhea australis*, which grows in many districts of Victoria ; *Xanthorrhea hastilis* and *Xanthorrhea arborea*. The resin is distinguished as *red* or *yellow* accroides. The yellow variety comes from *Xanthorrhea australis* and the red variety from *Xanthorrhea hastilis* and *Xanthorrhea arborea.* All the varieties dissolve in alcohol, giving strong yellow solutions, for which reason they are employed in varnish making. They have a pleasant aromatic odour. Nitric acid has a strong action on the resin, the principal product of the reaction being picric acid.

**GUM ARABIC.**—Under this name there comes into the English market, from African ports chiefly, a gum which is of great value and much used on account of the fact that it is almost the only commercial gum which is completely soluble in water and yields a strongly adhesive mucilage. Another name for this gum is *gum acacia*, as it is yielded by various species of *Acacia* trees. Gum arabic is, however, the name by which it is best known in the trade.

There are many species of *Acacia* trees profusely distributed over many of the tropical portions of Africa, Asia and Australia, and all of them are producers of gum. The gums from various species of *Acacia* vary a little in appearance, but all are more or less soluble in water, yielding a mucilage which has strongly adhesive properties. The gums are distinguished in commerce by terms descriptive either of their place of origin or export, and of their quality, such as picked Turkey, white Sennaar, gum Senegal, Cape gum, Mogador gum, gum ghatti, Indian gum, brown Barbary, wattle gum, etc.

*Picked Turkey Arabic* and *White Sennaar Arabic* the produce of *Acacia Senegal*, a tree which grows in the Upper Nile regions and in Kordovan, where it is collected by natives and sent to Egyptian ports for export. The best qualities of gum, free from woody matter, pale in colour and tasteless, are what are known by these names. *Gum Senegal* is the produce of the same species of *Acacia* growing in the French province of Senegal. This variety is not of so good a quality as the last. It is generally of a dark colour, in larger pieces, and not so completely soluble in water. The great bulk is sent into France by way of Bordeaux, but little coming into England. The best qualities of both the sorts just noted are used for pharmaceutical, confectionery and other purposes. The commoner qualities are employed in calico printing, varnish making, and the preparation of mucilages. The true gum arabic comes chiefly from the Soudan, where it is found as the produce of two species of *Acacia*, the talch or talha tree (*Acacia stenocarpa*) and the soffar tree (*Acacia Seyal*) of the Arabs. Soudan, or as it is sometimes called Suakim, gum comes from the Upper Nile regions. It finds its way into commerce through Khartoum or through Suakim, which is a port on the Red Sea. Since the Soudan war the supply of this variety of gum arabic has become very small. *Morocco gum arabic* is said to come from the *Acacia gummifera*, but this is rather doubtful. It is obtained in but small quantities, and is chiefly imported by way of Mogador. In colour it is rather brownish, and is hence often named brown Barbary gum. It is somewhat larger in size than most other gums. *Cape gum :* The doorboom, *Acacia horrida*, one of the commonest trees in South Africa, yields a large quantity of a brownish gum, which sometimes finds its way into the English market under the name of Cape gum. It is used very largely in South Africa in place of gum arabic. It differs from the typical gum arabic in not being so completely soluble in water. *East Indian gum arabic :* Much of what finds its way into English commerce as East Indian gum is really derived from East African sources, which are in the first instance exported to Aden or Bombay, and from thence to England. In its general characteristics this variety does not differ from Soudan or Suakim gum. Several species of *Acacia* flourish in India, and these yield gum which is used locally, and but little, if any, finds its way to England. About these Indian gums little is known as regards their characteristics and composition. The *Acacia arabica* grows in the provinces of Bengal, Deccan and Coromandel, and yields a gum of fairly good quality. The *Acacia catechu*, the cutch tree, yields a darkish coloured gum, which is otherwise equal to gum arabic in quality. The *Acacia speciosa* yields a gum known in India as *gum siris*, which is stated to have some good qualities. Besides those just noted there are other species of *Acacia* growing in India which yield gum in small proportions ; of these little is known. Mention may be made here of *gum Ghatti*. This is sometimes met with in England, although the greater portion of that which is collected is used locally. This gum, although resembling gum arabic in appearance, yet differs from it in not being completely soluble in water. When this gum is placed in water it swells up forming a voluminous jelly-like mass, with little adhesiveness. The uses of gum Ghatti are very limited. In Australia several species of *Acacia* grow, chief among which are *Acacia decurrens*, *Acacia pycnantha*, *Acacia homalophylla*, and others. They are generally known as wattle trees, and the gums from them as wattle gums. As a rule they are of good quality.

The following description is applicable to nearly all the varieties of gum arabic found in trade : It occurs in roundish or ovoid, or even in vermicular-shaped pieces of various size

The surfaces always have a glistening appearance. In colour gum arabic varies much, from pale almost colourless pieces in the best sorts to dark brown in some of the common qualities of Barbary and Senegal gum. It is somewhat friable, although some gums are less so than others.

Gum arabic is quite soluble in water, although it is possible to find some lots which contain a small proportion of insoluble gum. The best qualities take about 1½ times their own weight of water for solution, when they form a thick viscous mucilage. Gum arabic is insoluble in alcohol. If this body be added to aqueous solutions it causes the precipitation of the gum. The addition of a solution of sub-acetate of lead to gum solutions causes the formation of a white opaque jelly. Alumina sulphate added to solutions of gum makes them more viscous and more adhesive in their properties. Iodine does not produce any colouration in gum solutions. When boiled with nitric acid gum is converted into mucic and oxalic acids. Gum solutions boiled with dilute sulphuric acid are decomposed, dextrine and sugar being formed.

Gum arabic consists essentially of arabine, a compound of lime with arabic acid ($C_{12}H_{22}O_{11}$). Besides this compound there is also present traces of sugar, dextrine, colouring matters, a little tannin, and a small quantity of mineral matter.

The quality of a sample of gum is best determined by an examination of its colour, appearance, solubility in water, the consistence of its solution and its adhesive properties.

**GUM BENZOIN.**—This gum, also known as gum benjamin, is a balsamic resin obtained from a tree, the *Styrax benzoin*, which grows abundantly in Sumatra, Java, Borneo, Siam and adjacent countries. The resin is extracted from the trees by the Malays by making incisions, from which the resin flows out. One tree will usually give about 3 to 4 lb. annually for about nine years. For the first three or four years the resin is of superior quality, of a yellowish-white colour, soft and fragrant in odour. After four years the quality of the resin deteriorates by its becoming harder, darker in colour, and less fragrant. After nine years the product is not worth collecting.

The benzoin which comes into England is imported almost entirely from Siam and Sumatra. There is some difference in the appearance, properties and composition of these two varieties of benzoin.

**Siam Benzoin** is found in the form of agglutinated, flattened, somewhat opaque white tears, or in large blocks consisting of white masses distributed through an amber-coloured translucent matrix. It is brittle and has a strong vanilla-like odour, which is very characteristic. Heat softens and then melts it, the melting point being 100° C., while it is soft at 75° C. It is soluble in alcohol and ether, gives off large quantities of benzoic acid when heated, benzoin, in fact, being the raw material for making that acid. Besides benzoic acid the resin contains some woody matter, a little cinnamic acid, and a small quantity of resin.

**Sumatra Benzoin** differs from Siam benzoin in several respects. It is always found in trade in large blocks, having white masses scattered through a dark-coloured matrix. Its odour is not so strong as that of Siam benzoin, and it does not melt so easily. In composition it is rather more complex. It usually contains about 12 to 15 per cent. of woody matter. The resinous matter consists largely of cinnamic acid, for the preparation of which it may be employed. There are also present cinnamates of resinotannol and benzoresinol. The two latter bodies are converted by hydrolysis into cinna acid, and the alcohols from which picric acid can be made by the action of nitric acid.

Benzoin is employed in the preparation of spirit varnishes for the purpose of imparting to them a fragrant odour.

**GUM ELEMI.**—Under the name of gum elemi there is used in varnish-making several resinous products derived from various trees and imported from different countries.

**Manila Gum Elemi.**—This is the typical resin, and the one commonly understood when gum elemi is referred to. It is a product of the Philippine Isles, and is chiefly imported by way of Manila. The tree which furnishes it is the *Canarium commune* of the botanists, and grows principally in the Island of Luzon, although met with in the other islands of the Philippine group. When pure and of good quality gum elemi is white, but often commoner qualities are met with which have a grey colour. The resin is soft and has a granular appearance, with a slight but pleasant odour, and a slight flavour of that of turpentine. When exposed to the air the resin hardens on account of the loss of its volatile constituent, and loses some of its odour. When subjected to distillation elemi gives off about 10 per cent. of a volatile liquid, which resembles turpentine in its characters. When heated elemi begins to soften at from 75° to 80° C., and becomes liquid at 120° C. It is partially soluble in alcohol, and more readily in ether and other solvents.

It is employed in varnish making to give elasticity or toughness to the coats of varnishes made with hard resins like shellac and sandarac.

**Mexican Elemi** is obtained from the *Amyris elemifera*, and, beyond that it is somewhat of a darker colour and a little harder, it closely resembles the Manila elemi in appearance and properties. It is but rarely met with on the English market.

Elemi is also obtained in small quantities from Brazil and Mauritius. Of the source of these varieties not much is definitely known. They are not regular articles of commerce, and are only occasionally met with.

**GUM MASTIC.**—This resin comes from the lentisc tree, *Pistachia lentiscus*, which grows abundantly on the coasts of the Mediterranean, in Spain, Portugul, Italy, Greece, North Africa, etc. The principal portion of the mastic of commerce is exported from the Island of Chios, and is collected in the surrounding islands. The mastic tree is rather shrubby in habit, growing to a height of from four to five feet. The resin is contained in the bark, which has numerous resin vessels in it, the resin readily flowing out on incisions being made. From June to August the natives of the districts in which the tree grows make vertical incisions in the bark of the stem and branches and take means to keep these open. The resin flows freely and soon hardens. At intervals of two or three weeks the resin is carefully collected in baskets. The important point is to keep it clean, and every care is taken to ensure this desirable end. Sometimes the resin exudes spontaneously from the tree. This is collected and considered to be of superior quality. A tree in good condition will often yield 8 to 10 lb. per annum during the dry season. A wet season makes a considerable difference in the yield of resin, in some cases reducing the yield by one-half.

Gum mastic makes its appearance in commerce in several forms. 1. *Cake*, which is in the form of large pieces, and is the best quality of mastic. 2. *Large mastic:* This and the last variety is largely used as a chewing gum. 3. *Small mastic:* This variety usually occurs in small tears of a cylindrical shape, and is the variety commonly met with in this country and employed for making varnishes.

Gum mastic is usually found in cylindrical tears of from ¼ to ½ inch long, mostly of a pale colour; but, occasionally, pieces having a greenish tint are met with. On keeping there is a tendency for the colour to darken. Although the main body of the resin is clear and transparent yet the surface is often powdery and the resin appears opaque. It is brittle and breaks with a conchoidal fracture. Its odour is pleasant and balsamic. When placed in the mouth it softens readily, a character which distinguishes it from sandarac, a resin that closely resembles it in form. The specific gravity of mastic is about 1·056 to 1·060. Its melting point ranges from 105° to 120° C. (221° to 248° F.), but it softens below the boiling point of water.

Gum mastic is soluble in turpentine, alcohol, amyl alcohol, chloroform and acetone. It is insoluble in ether. It is used in making varnishes for pictures, the usual solvent being turpentine. Mastic leaves a hard but brittle coating when used as a varnish material. A mixture of mastic varnish made with turpentine and linseed oil forms the medium often used by artists under the name of *megilp*.

**GUM THUS** is the name given to the best qualities of the crude turpentine got from pine trees. See under *Turpentine*. It is sold in commerce to a small extent for the purpose of making varnishes. It occurs in a mass of creamy colour, smelling of turpentine. It is soft in consistency, but on exposure to air it gradually hardens and becomes brittle from loss of the volatile turpentine. Gum thus is soluble in almost all solvents. It is of course a mixture of resin and turpentine, both of which will be found described below. See *Rosin; Turpentine*.

**GUM TRAGACANTH.**—This gum comes from several species of *Astragalus*, of which the commonest is *Astragalus gummifera*, growing chiefly in Lebanon, Syria, Central Asia Minor and Armenia. Other species of *Astragalus* growing in Judea, Syria and Persia also yield tragacanth. This gum is exported chiefly from Bagdad. Gum tragacanth, or gum dragon as it is often named, occurs in two forms. 1. *Leaf gum*, in strips of about ½ to ¾ inch wide and from 2 to 3 inches long. 2. That known as *vermicelli gum*, in long round pieces. It is of a dull greyish colour, without odour or taste. Placed in cold water it does not dissolve, but swells up into a gelatinous mass. If gum tragacanth be first soaked in water for some time and then boiled a thick viscid liquid is obtained. This is much used by calico printers for thickening their printing pastes with. Six to seven parts of the gum will form a thick liquor with 100 parts of water. It is stated that gum tragacanth and similar insoluble gums can be readily dissolved with the aid of peroxide of hydrogen. Alkaline solutions will dissolve this gum, but it is insoluble in alcohol. The essential principle of gum tragacanth has been named bassorine, and the formula, $C_6H_{10}O_5$, has been assigned to it. There is usually present in this gum a little arabine. Gum tragacanth is not employed in varnish-making, but finds its chief use in the printing of textile fabrics.

**GYPSUM.**—This is the name given to the hydrated calcium sulphate, $CaSO_4, 2H_2O$, which occurs naturally in great abundance in a great many localities. In this country it is found at Chellaston near Derby, Aston-on-Trent, and other places in Derbyshire; at Newark-on-Trent, in Nottinghamshire; Fauld, in Staffordshire; Netherfield, in Sussex. There are large deposits in France, more especially in the district round Paris.

Gypsum is the sulphate of calcium, $CaSO_4$, but it differs from the corresponding barium compound, barytes (see *Barytes*), in containing water of crystallisation, and, therefore, the mineral has the formula given above. Gypsum contains :—

| | Per Cent. |
|---|---|
| Sulphuric anhydride, $SO_3$ . . . . | 46·51 |
| Calcium oxide, CaO . . . . . | 32·56 |
| Water, $H_2O$ . . . . . . | 20·93 |

It is found in several forms. The most useful form is that in large amorphous crystalline masses of a white or nearly white colour and more or less opaque. It is this variety which is most useful as a pigment for filling cotton cloths and in making plaster of Paris. It often occurs more or less coloured, the colouring matter often being in streaks. This variety is known as alabaster or Derbyshire spar, and is used for making ornaments. Satin spar is a variety of gypsum which occurs in long fibrous silky-looking pieces, which, when ground, may be used as a pigment. Selenite is a variety occurring in transparent flaky pieces, and having the property of cleavage so highly developed that it may be split into very thin flakes. This variety is chiefly used for optical purposes. In all its forms gypsum is a soft mineral, readily scratched by the finger nail and easily ground into a white powder. Its specific gravity varies from 2·28 to 2·33.

Under a variety of names, such as gypsum, mineral white, terra alba, etc., this substance is employed as a pigment, for which purpose it is ground into a fine powder in a suitable grinding-mill, and may be levigated to obtain the finest qualities. In this form it is also employed for filling paper, cotton cloths, etc.

The colour of gypsum is a good white, somewhat bluer in tone than barytes, but not so blue as white lead. It is lighter than either barytes or white lead, but heavier than china clay or zinc white. As a pigment it is only suitable for use with water as a vehicle; when used with oil it loses its opacity or body and becomes more or less transparent. It is quite permanent when exposed to light and air, and being neutral in its properties it can be mixed with any other pigment without bringing about any change.

Gypsum is slightly soluble in water, about 1 part in 500. This solution will give a precipitate of calcium oxalate on addition of ammonium oxalate and a precipitate of barium sulphate on addition of barium chloride. It is more easily soluble in dilute hydrochloric and nitric acids, long continued boiling with which gradually dissolves it without any effervescence. Gypsum is also soluble in ammoniacal solutions.

When heated gypsum loses its water of crystallisation, and then forms a white amorphous powder, which, however, has a strong affinity for water, with which it again enters into combination forming a hard solid mass. This property is largely taken advantage of for a great variety of purposes, such as making cements, moulds for casting metals, etc., and ornaments, and for decorative purposes. The heated gypsum is sold for this purpose under the name of *plaster of Paris.*

Gypsum may be distinguished by the following tests: It is practically insoluble in water. When boiled with hydrochloric acid there is gradual solution without any effervescence. The solution will give a white precipitate with barium chloride insoluble on boiling, and a white precipitate on the successive addition of ammonia and ammonia oxalate. A little of the solution held on a piece of platinum wire in the lower portion of a Bunsen flame will impart a reddish colour to the flame. Generally the gypsum of commerce is nearly pure, containing about 78·5 per cent. of calcium sulphate, the rest being water of crystallisation; occasionally traces of iron, silica and alumina may be met with.

Besides occurring naturally, calcium sulphate is obtained as a by-product in some chemical operations, and this variety is sometimes sold for pigment purposes. If anything this artificial gypsum is better than the natural variety, as it is more amorphous in structure, whiter in colour, and has better body and covering power. Satin white is a mixture of calcium sulphate and alumina, prepared by adding milk of lime to alum solutions, largely employed in the paper industry for filling and staining.

## H.

**HEMPSEED OIL.**—This oil is obtained from the seeds of the hemp plant, *Cannabis sativa*, which is grown in many countries on account of the fibre (hemp) which it yields, and which is much valued for making ropes and canvas, etc. The seed contains from 15 to 25 per cent. of oil.

Hempseed oil, when fresh, has a greenish-yellow tint. On keeping, the colour changes to a brownish yellow. The odour and taste are somewhat unpleasant. The specific gravity ranges from 0·925 to 0·931. It becomes turbid at a temperature of $-15°$ C., and solid at $-25°$ C. Mixed with strong sulphuric acid great heat is developed, the rise in temperature being about 100° C. It absorbs a large proportion of iodine, 143 to 144 per cent. of its weight, showing that it consists chiefly of the glycerine of linolic acid. The chemistry of hempseed oil has not yet been fully investigated. The mixture of fatty acids it contains has been named chanvroelic acid. It has, however, been shown that hempseed oil contains linolic and linolenic acid. Its drying properties are fairly good, but not equal to those of linseed oil. It is not much used in this country as a paint oil, partly on account of the price and partly on account of its dark colour. Where the hempseed is grown the oil is employed as a paint oil.

**HYDROCHLORIC ACID.**—This very important acid is largely used in the colour trades. It is also known as "muriatic acid" and as "spirits of salts". The pure substance is a colourless, strongly fuming gas composed of the elements hydrogen and chlorine in equal atomic equivalents, or 1 part of hydrogen and 35·5 parts of chlorine by weight, and having, therefore, the formula, $HCl$. The commercial product is a solution of this gas in water. Hydrochloric acid is prepared by heating common salt (sodium chloride) with sulphuric acid and dissolving the evolved gas in water, which will take up about 500 times its own volume of the gas. When pure it is a colourless liquid, fuming slightly and having a strong acid smell. The low grades of the commercial acid, which are largely made as by-products in the manufacture of soda from salt by the Leblanc process, have a yellow colour, due partly to the presence of iron and partly to the presence of organic matters. The commercial acid frequently contains arsenic, sulphuric acid and salt.

The pure acid usually has a specific gravity of 1·18 (36° Tw.), and contains 36·01 per cent. of actual hydrochloric acid. The ordinary commercial acid is usually about 1·16 specific gravity (32° Tw.), and contains 32·02 per cent. of $HCl$. The strongest solution it is possible to make has a specific gravity of 1·2265 (45·3° Tw.), and contains 45·6 per cent. of the acid.

The following table gives some information as to the gravities and strengths of hydrochloric acid:—

SPECIFIC GRAVITY OF HYDROCHLORIC ACID AT 60° F.

| Specific Gravity. | Twaddell. | Per Cent. of HCl. | One Gallon Weighs in lb. |
|---|---|---|---|
| 1·030 | 6 | 6·11 | 10·30 |
| 1·035 | 7 | 7·10 | 10·35 |
| 1·040 | 8 | 8·10 | 10·40 |
| 1·045 | 9 | 9·10 | 10·45 |
| 1·050 | 10 | 10·09 | 10·50 |
| 1·055 | 11 | 11·09 | 10·55 |
| 1·060 | 12 | 12·09 | 10·60 |
| 1·065 | 13 | 13·08 | 10·65 |
| 1·070 | 14 | 14·08 | 10·70 |
| 1·075 | 15 | 15·08 | 10·75 |
| 1·080 | 16 | 16·07 | 10·80 |
| 1·085 | 17 | 17·07 | 10·85 |
| 1·090 | 18 | 18·07 | 10·90 |
| 1·095 | 19 | 19·07 | 10·95 |
| 1·100 | 20 | 20·06 | 11·00 |
| 1·105 | 21 | 21·06 | 11·05 |
| 1·110 | 22 | 22·06 | 11·10 |
| 1·115 | 23 | 23·05 | 11·15 |
| 1·120 | 24 | 24·05 | 11·20 |
| 1·125 | 25 | 25·05 | 11·25 |
| 1·130 | 26 | 26·04 | 11·30 |
| 1·135 | 27 | 27·04 | 11·35 |
| 1·140 | 28 | 28·04 | 11·40 |
| 1·145 | 29 | 29·03 | 11·45 |
| 1·150 | 30 | 30·03 | 11·50 |
| 1·155 | 31 | 31·03 | 11·55 |
| 1·160 | 32 | 32·02 | 11·60 |
| 1·165 | 33 | 33·02 | 11·65 |
| 1·170 | 34 | 34·02 | 11·70 |
| 1·175 | 35 | 35·01 | 11·75 |
| 1·180 | 36 | 36·01 | 11·80 |
| 1·185 | 37 | 37·01 | 11·85 |
| 1·190 | 38 | 38·01 | 11·90 |
| 1·195 | 39 | 39·00 | 11·95 |
| 1·200 | 40 | 40·00 | 12·00 |

When the strong acid is boiled it loses hydrochloric acid gas and becomes weaker until the liquid has a specific gravity of 1·10 (20° Tw.), containing 20·06 per cent. of actual acid when it distils unchanged.

Hydrochloric acid is a powerful acid. It dissolves in the cold such metals as zinc, iron, magnesium, nickel, aluminium and the alkali metals forming the chlorides with the evolution of hydrogen. When boiling it will dissolve tin, lead, copper, bismuth and many other metals.

Hydrochloric acid dissolves nearly all oxides forming the corresponding chlorides.

The metallic chlorides are a group of very valuable salts, many finding considerable uses in various industries. With the exception of three, *viz.*, the chlorides of silver, lead and mercurous chloride, the chlorides of all the commoner metals are soluble in water. Lead chloride is soluble in boiling water, but as the solution cools it falls out again in the form of transparent needle-like crystals.

The presence of hydrochloric acid and of soluble chlorides is indicated by the formation of a white, curdy precipitate, when a solution of silver nitrate is added to the liquid. This precipitate is insoluble in nitric acid, but is readily soluble in ammonia, sodium hyposulphite and in potassium cyanide.

Commercial hydrochloric acid should have a specific gravity of 1·160 (32° Tw.). It ought to give but a slight precipitate with barium chloride, showing the presence of sulphuric acid or sulphates, and with potassium ferrocyanide but a faint blue colouration, showing the presence of iron. The amount of acid it contains can be determined by weighing 5 grammes, diluting this to 250 c.c., taking 25 c.c., and titrating with a standard solution of caustic soda, using phenol-phthalein or litmus as indicator. One c.c. of the standard alkali solution is equal to 0·0365 gramme hydrochloric acid.

The amount of sulphuric acid or sulphates is obtained by taking 5 grammes, diluting with water, adding barium chloride, filtering off, washing, drying, burning, and weighing the precipitate of barium sulphate which is thus got. The weight of barium sulphate found multiplied by 0·42 gives the weight of sulphuric acid in the hydrochloric acid. Any saline salts in the acid can be determined by evaporating off 2 grammes of the acid and weighing the residue which is left.

## I.

**IMPERIAL RED.**—Under this name has been sold red pigments made from eosine, orange lead and barytes. It, therefore, has a similar composition to royal red. See *Royal Red.*

**INDIAN RED** is the name originally given to a dark red pigment consisting chiefly of oxide of iron found in India. The name has now come to be applied to dark red pigments prepared from ochres, waste iron liquors, ferrous sulphate, etc., in various ways. From ochre and ferrous sulphate it is made by heating, or, as it is termed, calcining, it at a considerable heat until the desired shade is obtained. From waste iron liquors the pigment is made by precipitation with lime and calcining the precipitate so obtained.

The composition of Indian red will, of course, vary with the source from which it is derived. The following are some analyses of such reds made by the author:—

1. *Natural Indian Red.*

| | Per Cent. |
|---|---|
| Ferric oxide, $Fe_2O_3$ . . . . | 94·71 |
| Alumina, $Al_2O_3$ . . . . | 1·60 |
| Silica, $SiO_2$ . . . . . | 2·80 |
| Calcium carbonate, $CaCO_3$ . . . | 0·39 |
| Water, combined . . . . | 0·69 |
| Water, hygroscopic . . . . | 0·14 |

2. *Indian Red, Manufactured.*

| | Per Cent. |
|---|---|
| Ferric oxide, $Fe_2O_3$ . . . . | 43·59 |
| Calcium sulphate, $CaSO_4$ . . . | 53·94 |
| Water, combined . . . . | 1·30 |
| Water, hygroscopic . . . . | 1·05 |

This sample was prepared from waste iron liquors containing ferrous sulphate by precipitation with lime and heating the precipitate to the required degree.

3. *Indian Red made from Ochre.*

| | Per Cent. |
|---|---|
| Ferric oxide, $Fe_2O_3$ . . . . | 63·91 |
| Alumina, $Al_2O_3$ . . . . . | 0·60 |
| Calcium carbonate, $CaCO_3$ . . | 3·31 |
| Barytes, $BaSO_4$ . . . . | 21·11 |
| Water, combined . . . . | 10·65 |

These three analyses will serve to show that Indian reds have no definite chemical composition. Beyond the fact that the essential constituent is ferric oxide no standard of composition can be laid down for Indian red. Usually the more ferric oxide the pigment contains the stronger is it in colouring power, and often in covering power also. This is most important to the painter, for Indian red is mostly used as a staining colour, and, therefore, the greater the colouring power the better is the sample for use in painting.

Seeing that the chemical composition of Indian red is of no moment as a criterion of its quality, it will rarely be necessary to make a chemical examination of a sample of Indian red; but, if such be desired, it may be done on the usual lines of chemical analysis, and the analyses quoted above will serve to show what constituents to look for. Under *Ochres* a general scheme of analysis will be found, which is also applicable to Indian reds. Indian reds should be examined for strength of colouring power, covering power, etc. This may be done by the methods described under *Testing Pigments.*

When used as a pigment Indian red possesses most valuable properties. It works well in either oil or water, and possesses good covering powers, although this will naturally vary in different samples. It is perfectly permanent, and may be ranked among the most permanent pigments known. It is quite neutral in its properties, and may be mixed with all other pigments without producing any change in them. See also *Oxide Reds*, *Ochres*, *Venetian Red.*

**INDIAN YELLOW** is a most curious pigment prepared from the urine of Indian cows fed on a particular plant, which causes them to secrete a urine full of a yellow colouring matter. This pigment is not now used.

**IRON.**—Chemical symbol, Fe ; atomic weight, 56. This important metal enters into the composition of a large number of pigments : ochres, oxide red, Indian reds, Venetian red, Prussian blue, etc. As a metal it forms a valuable constructive material, probably the most important that is known. In union with other elements, oxygen, chlorine, sulphur, etc., it forms a number of compounds which are much used in various industries. In combination with oxygen iron forms four oxides : ferrous or monoxide, $FeO$ ; the ferric or sesquioxide, $Fe_2O_3$ ; these are basic oxides capable of combining with acids to form what are known as the iron salts ; the tetroxide or magnetic oxide, $Fe_3O_4$ ; and the trioxide, $FeO_3$, which latter is an acid oxide, and when combined with powerful bases like soda or potash forms the ferrates. Of these oxides the basic are the most important. These will be described more fully under *Iron Oxides.*

When iron is treated with dilute acids it is attacked, hydrogen gas is evolved, and the corresponding ferrous salt is formed. When iron is exposed to the air it gradually undergoes oxidation, the red or ferric oxide is formed and the iron is said to *rust*. This property of iron is one of the disadvantages which attend the use of iron as a constructive material. This rusting of iron takes place most readily in moist climates. In dry climates where there is little moisture in the atmosphere it proceeds but slowly. Those compounds of iron which are of use in the decorative arts are described below. See Andés' *Iron-Corrosion, Anti-Fouling and Anti-Corrosive Paints.*

**IRON OXIDES.**—As stated under *Iron* there are four iron oxides, two only of which are of any interest to the colour maker and decorator. These are the two basic oxides, the ferrous oxide, FeO, and the ferric oxide, $Fe_2O_3$.

**Ferrous Oxide,** FeO, is not known in the anhydrous condition, as represented by the formula here given. When ammonia or a solution of the caustic alkalies is added to one of a ferrous salt a pale green precipitate of a hydrated oxide, which is generally assumed to be the ferrous hydroxide, $FeH_2O_2$, is obtained. This precipitate is, however, very unstable. On exposure to the air it absorbs oxygen, and passes into the ferric oxide with such rapidity that its true chemical composition must always remain a matter of doubt. This element of instability is also communicated to the ferrous salts, which are obtained by dissolving this oxide or the metal itself in acids. Their solutions are prone to undergo change; oxygen is absorbed, a little ferric oxide is precipitated, and a ferric salt remains in solution. This is the reason why so few ferrous compounds occur in nature.

When iron or the green oxide are dissolved in acids ferrou
formed, of which the sulphate, $FeSO_4$, and the chlorid

$FeCl_2$, may be taken as types. In the ferrous salts iron plays the part of a dyed base. The most important compound is the sulphate which is commonly known as copperas. See *Ferrous Sulphate.*

The **Ferric Oxide** occurs naturally in great abundance in a variety of forms (anhydrous and hydrated), as the minerals hæmatite, specular iron ore, limonite, bog iron ore, etc. Some varieties of these minerals, if of sufficient brightness and softness, are used as pigments for painters. In the hydrated form ferric oxide is found as the colouring principle in ochres, siennas, umbers and similar natural pigment colours. Ferric oxide is soluble in hydrochloric acid, sulphuric acid or nitric acid, forming the corresponding ferric chloride, sulphate or nitrate, as the case may be. The degree of solubility is, however, rather variable, some specimens of the natural oxide being freely soluble, while others are difficultly soluble. The same observation also applies to the artificial ferric oxides, which are obtained by heating ferrous sulphate or precipitated hydrates of iron. It is found that if the oxides have been subjected to a moderate heat only they become freely soluble in acids; while if they have been strongly heated they are almost insoluble in acids and require very prolonged digestion to be dissolved. This difference of solubility may be noticed in comparing the bright reds, rouge, or colcothar with the so-called purple oxides. The former are produced at a comparatively low temperature, and are soluble without much difficulty; while the latter require a stronger heat and a longer time, and are very difficultly soluble. The solutions have in all cases a brownish-yellow colour. When ammonia or solutions of caustic potash or caustic soda are added to solutions of ferric salts a brownish-red precipitate of the ferric hydroxide (to which the formula, $Fe_2H_6O_6$, is usually assigned) is obtained. On ignition this loses its water of hydration and the anhydrous oxide is left behind.

Ferric oxide is the essential constituent of a large number of pigment colours, such as *Indian red, Oxide reds, Turkey red, Scarlet red, Venetian red*, etc., which will be found noticed in their proper place.

The following are the distinguishing features of the salts of the two oxides:—

**Ferrous Salts.**—Colour green, rather unstable, especially in the form of solution, which gives a greenish precipitate of $FeH_2O_2$ with ammonia; the precipitation is not complete and the precipitate turns brown on exposure to the air, owing to oxidation to ferric oxide. Potassium ferrocyanide gives a light blue precipitate of ferrous ferrocyanide; potassium ferricyanide gives a dark blue precipitate of ferrous ferricyanide (Turnbull's blue), ammonium sulphocyanide produces no change.

**Ferric Salts.**—Colour orange to red, stable. Solutions give a brownish-red precipitate with ammonia, the precipitation being complete. Potassium ferrocyanide gives a dark blue precipitate of ferric ferrocyanide (Prussian blue); potassium ferricyanide does not give a precipitate, but turns the colour of the solution more brownish; ammonium sulphocyanide gives a deep red colour to the solution. The blue precipitates with the ferrocyanide and ferricyanide of potassium are exceedingly characteristic of iron and form very delicate tests for that metal.

**IRON REDS.**—As stated above many red pigments contain the ferric oxide as their essential constituent; these pigments are commonly known as the iron reds. They are in general excellent, quite permanent when exposed to light and air, and can be mixed with all other pigments without being either themselves changed or bringing about any change in the other pigments. They mix well with oil, water or any other vehicle in paints or varnishes. As regards their colouring or staining power, and body or covering power they vary very greatly, some having these properties developed in a high degree, others possessing them but slightly; those which approximate most closely to pure oxide of iron in their chemical composition have these powers in the highest degree, but much depends upon the physical condition of the pigment.

**IRON SCALES.**—These are the scales, consisting partly of oxide and partly of metal, which are obtained in the forging of iron. They are employed in the pottery manufacture as a colouring agent.

**IRON SULPHATE.**—See *Ferrous Sulphate.*

**ITALIAN PINK** is the name given to a yellow pigment made from Persian berries or quercitron bark by means of alum and whiting. It is similar to, if not identical with, *Dutch Pink* (which see). This pigment is not used now.

**IVORY BLACK.**—This pigment is prepared from ivory chippings or waste by heating them in a closed vessel to a red heat. The result is a black of very fine quality, fine in texture and working well. It is much prized by artists. In its chemical composition it resembles bone black. The following are analyses of ivory blacks made by the author:—

| | Per Cent. | Per Cent. | Per Cent. |
|---|---|---|---|
| Water . . | 6·15 | 7·61 | 8·37 |
| Mineral matter . | 76·48 | 77·21 | 73·98 |
| Carbon . . | 17·37 | 15·18 | 17·65 |

It is difficult, if not impossible, to distinguish ivory black from bone black; the latter has a somewhat browner hue than the former.

## J.

**JAPANESE LACQUER.**—The highly lustrous coat of lacquer for which the Japanese cabinetmaker is famous is obtained from a product of the tree, *Rhus vernicifera*, and is commonly known as Japanese lacquer. It is not imported into this country. The tree is found growing all over the main island in fair abundance and in the other islands in lesser quantity. The trees are the subject of cultivation, which is often carried on by companies formed for that purpose. The tree takes ten years to grow from seed, and will yield at the end of that time about 3½ oz. of lacquer. By a process of grafting the growth can be quickened and thereby the yield of lacquer increased. The trees grown in the districts of Tsugaru, Nambu, Akita and Aidzu yield the best lacquer; this variety is mostly used in Kioto and Osaka, which are the great centres of the lacquer ware industry.

In June of each year the tappers go round the plantations and make a number of incisions in the trees, from which the sap then flows; the quality varies. The number of cuts made is usually about twenty, sometimes more; the sap from the first cuts is the worst, that from the last few cuts is thin, while that from the middle cuts is of the best quality. The cutting of the tree generally kills it, although by making fewer incisions the life of the tree may be prolonged another year. The second year's sap is not of so good a quality as the first year's sap; hence it is not the rule to collect a second year's supply from the same tree. The tree, after being cut for lacquer, is used for firewood, making cabinet ware, furniture, etc.

Two kinds of lacquer are distinguished, known as *Kiurushi* or tree lacquer and *Seshime* or branch lacquer, these terms indicating which portion of the tree the lacquer is obtained from.

The crude lacquer contains some water and has to undergo a process of rectification before it can be used for lacquering. The crude lacquer is a liquid of about the colour and consistency of cream; if exposed to the sun for some days it loses this colour and becomes almost black, if not quite so, and at the same time more or less transparent; in this condition it will not dry if used for lacquering articles. If, however, some water be mixed with it two or three times a day for two or three days, and it be exposed to the air for this water to evaporate off, then the lacquer acquires the property of drying and may be used for lacquering. Branch lacquer does not dry so well as tree lacquer, and is, therefore, rarely used alone; mixtures of the lacquer are made with other ingredients and sold under a variety of names for special kinds of cabinet ware.

Old lacquer is more difficult to treat than new lacquer. One of the peculiarities of Japanese lacquer is that it will not dry and become hard in a dry atmosphere; it requires a damp one to harden properly.

As might be expected the lacquer varies in composition. This may arise partly from natural causes and partly from the fact that the lacquer merchants rarely sell the lacquer in the same condition as they receive it, but generally mix it with other bodies. Two analyses of Japanese lacquer have been published. Mr. S. Isima Ishimatsu gives the following as the composition of a sample of Yoshimo lacquer, which is one of the best varieties. The specific gravity was 1·002 at 20° C., and it contained :—

| | Per Cent. |
|---|---|
| Urushic acid | 85·15 |
| Gum arabic | 3·15 |
| Nitrogenous matter | 2·28 |
| Water and volatile matter | 9·42 |

Mr. J. Takayma analysed a sample and found it to contain:—

| | Per Cent. |
|---|---|
| Urushic acid | 64·07 |
| Gum arabic | 6·05 |
| Nitrogenous matter | 3·43 |
| Oil | 0·23 |
| Water and volatile matter | 26·22 |

The higher the proportion of urushic acid the lacquer contains the better is its quality. The formula of urushic acid is $C_{22}H_{31}O_3$.

The best account of the manufacture and use of Japanese lacquer is the report of Mr. John J. Quinn, Consul at Hakodate, on the *Lacquer Industry of Japan*, published in 1892, to which readers are referred for further information.

**JAPAN WAX.**—This product is prepared in Japan and in China from the berries of several species of sumach trees, *Rhus succedanea*, *Rhus vernicifera*, *Rhus sylvestris*, *Rhus acuminata*, etc. The berries are collected, crushed, and then treated with boiling water. The wax melts and collects on the top of the water. It is collected and purified by treatment with more boiling water. It is imported into this country in the form of slabs.

Japan wax is a creamy-coloured, hard substance, readily breaking with a conchoidal fracture. Its lustre is but slight. There are indications that Japan wax has a slight crystalline structure, as, on keeping, the surface often becomes covered with crystals. The colour of the wax deepens on keeping.

The specific gravity of Japan wax varies very considerably, and at 15° C. (60° F.) ranges from 0·970 to 0·993. This difference is, probably, due to the wax being obtained from different species of sumach trees. At 100° C. (212° F.) the specific gravity is 0·875. The melting point is 53° to 54° C. (127·5° to 129° F.). The solidifying point is some 4° to 5° lower.

It is a misnomer to call this body a wax, for its chemical composition (being almost pure palmitate of glyceryl, $C_3H_5\ (C_{16}H_{31}O_2)_3$), shows it to be a true fat. It owes its name of wax to its having the same outward physical properties.

Japan wax is insoluble in cold alcohol. It dissolves in boiling alcohol, separating out again on cooling in the form of crystals. It dissolves freely in ether, petroleum spirit, benzene, carbon tetrachloride and other solvents, like the ordinary fats.

When boiled with solutions of the caustic alkalies it undergoes almost complete saponification, there being usually only about 1 to 1·25 per cent. of unsaponifiable matter in it. It contains, besides the palmitate of glyceryl, free palmitic acid, from 3 to 9 per cent., small traces of stearin and arachin. It can be distinguished from the true waxes by the fact that it contains glycerine. Japan wax requires 21 to 22 per cent. of caustic potash to saponify it. It absorbs but a small quantity, 4 to 5 per cent., of iodine.

Japan wax is used in the manufacture of candles, furniture polish, etc.

**JAPANESE WOOD OIL.**—This oil is largely employed in China and Japan as a natural varnish for cabinet ware and wooden articles of all kinds. It is stated to possess drying properties in a very high degree, ranking higher than linseed oil in this respect. It is obtained from the seeds of the tree, *Aleurites cordata*, which is indigenous to Japan and China. Cold pressed oil has a pale yellow colour and not much taste or odour. Hot pressed oil has a dark brown colour and an unpleasant taste. Exposed to a temperature of – 18° C. (0° F.) it becomes slightly turbid.

The specific gravity of Japanese wood oil is 0·940 at 15° C. (60° F.). It requires 21 per cent. of caustic potash to saponify it. So far as it has been submitted to a chemical examination it has been found to yield the glycerides of oleic acid, $HC_{18}H_{33}O_2$, and of elaomargaric acid $HC_{17}H_{29}O_2$, an acid of the linolic series of fatty acids.

## K.

**KAOLIN**, the Chinese name for china clay. See *China Clay*.

**KAURI, COWREE.**—This is a most important varnish resin of comparatively recent introduction. It is obtained from New Zealand, principally in the province of Auckland, where it occurs as a fossil resin in the ground. The resin is the product of the New Zealand pine, *Dammara australis*, and allied species. The trees are found in various parts of the islands and yield resinous products; but the commercial kauri is essentially a fossiliferous body and is found most abundantly in those portions of New Zealand where the pines do not now grow. The resin is obtained by a process of digging. Very large blocks are sometimes obtained of from 100 to 200 lb. weight. As found the surface of the resin is covered with a crust of decayed vegetable matter and resin. This crust is removed before the resin becomes merchantable.

Besides the fossil resin kauri is obtained from the livin trees, but such "young" kauri, as it is called, is not as good for varnish making as the fossil resin.

Kauri comes into the market in pieces varying much in size, from a few inches to perhaps two feet, and in weight from 2 or 3 oz. to 1 cwt. There are many qualities, dependent on colour, transparency, etc. The best is known as "dial" kauri. In colour it varies but little, being mostly of a pale amber or pale brown. It is more or less opaque, although transparent samples are occasionally met with. It is usually homogeneous in structure, but streaked pieces are frequently met with. Its lustre varies from glassy to opaline. It breaks with a conchoidal fracture, and the freshly broken surfaces have a pleasant, fragrant odour, which is characteristic. The taste also is pleasant and aromatic. The "young kauri" resin is used in the colony by the Maories as a chewing gum.

The specific gravity of kauri is about 1·050, but it varies a little. It melts at from 360° to 450° F. On distillation kauri gives off about 1·4 per cent. of water and 16 to 20 per cent. of an oil of 0·9224 specific gravity, soluble in ether and amyl alcohol, but insoluble in alcohol: it is acted on by caustic soda.

Kauri is very largely employed in varnish making. It does not make as good varnish as copal; but, being easier to melt and the melted resin being much more easily soluble in oil, kauri varnishes are much easier to make. Kauri yields a varnish that dries well with a good hard and lustrous coat. It is not so durable when exposed to the air as copal varnishes. On this account it is mostly employed in making varnishes for furniture and indoor woodwork generally.

Petroleum spirit, alcohol, turpentine and benzol partially dissolve kauri and cause it to swell up into a white gelatinous mass. Chloroform has rather more solvent action, but does not completely dissolve it. Ether dissolves it completely. Different samples of kauri, however, behave differently with these solvents. Kauri which has been subjected to heat, so that it has lost some 25 per cent. of its weight, is soluble in ether, petroleum spirit, turpentine, benzol and chloroform.

**KIESELGUHR or FOSSIL EARTH.**—In several places there occur deposits of a white, greyish or greenish colour, of low specific gravity, consisting largely of silica, with a small proportion of organic matter, alkali and lime. When examined under the microscope this deposit is seen to consist of the minute siliceous skeletons of what are known as *Diatomaceæ*. The most notable of such deposits of kieselguhr is that which occurs at Naterleuss, between Hamburg and Hanover in Germany, from which the great bulk of what is used is obtained. Other deposits are known in Canada, America, etc. The crude material is dug out of the deposit, washed with water, and calcined in a specially constructed furnace or kiln. The finished product is then ready for use. Kieselguhr consists almost exclusively of silica. The following are some analyses :—

*German kieselguhr :—*

| | Per Cent. |
|---|---|
| Silica . . . . . . . | 90·05 |
| Oxide of iron and alumina . . | 1·50 |
| Organic matter . . . . . . | 3·10 |
| Water . . . . . . . | 5·35 |

*Canadian kieselguhr :—*

| | Per Cent. |
|---|---|
| Silica . . . . . . . | 92·00 |
| Oxide of iron and alumina . . | 2·50 |
| Water . . . . . . . | 5·50 |

It is quite insoluble in acids, and but slightly attacked by alkalies.

Kieselguhr is used for a great variety of purposes: in dynamite making, being capable of absorbing a large quantity of nitro-glycerine and still be dry to the feel; as a fireproof composition for safes, cooking stoves, etc.; as a non-conducting composition for use with steam boilers and steam pipes; as a filler in painting; in the manufacture of ultramarine; in soap making, and for many other purposes.

It may be distinguished by its lightness, insolubility in acids, and when examined under the microscope it shows the beautiful forms of the diatom shells.

**KING'S YELLOW.**—Under this name used to be sold the trisulphide of arsenic, $As_2S_3$, which was obtained as a fine yellow precipitate by passing a current of sulphuretted hydrogen gas through a solution of arsenious oxide in hydrochloric acid or soda. The pigment has now become obsolete and been replaced by the chrome yellows. It may be distinguished by the fact that it is insoluble in hydrochloric acid, but soluble in caustic soda, from which solution it is re-precipitated on adding acid. Marsh's test will detect the arsenic in this yellow.

## L.

**LAC.**—Lac is a resinous secretion found surrounding the twigs and branches of several trees in India and neighbouring districts. The secretion is formed from the sap of the tree, which sap is itself of a gummy or resinous nature, by the female of the lac insect, *Coccus lacca.* The insect punctures the bark of the tree and commences to secrete the lac, in which it soon becomes completely enveloped, throwing out to the air fine filaments by means of which it breathes; it then lays its eggs inside the deposit of lac and then dies. The young insects when they are born bore their way through the lac, and swarm over the branches and tree; the male insects are winged and can fly; the females are wingless and never go from the tree on which they are born. When they are impregnated by the male they proceed to secrete the lac and lay eggs as their mother did before them. A tree will supply nourishment to a great number of insects, but at the expense of its own vital powers; for, after a time, it begins to decay and then it ceases to support more insects. The distribution of the insects from tree to tree is carried on in various ways, partly by the insects themselves, by birds, etc.; while of late years artificial propagation has been largely carried on. The trees on which the lac insect grows are very varied; the chief are the Palas or dhak tree, *Butea frondosa;* the peepul tree, *Ficus religiosa;* the koosum tree, *Schleichera trijuga; Acacia arabica* and *catechu;* several species of croton trees, *Croton lacciferum, C. draco,* etc.; *Butea superba,* and several species of *Ficus* trees.

The principal proportion of the lac of commerce comes from India, but it is also obtained from other Asiatic countries; that from Siam has a great reputation for quality. It is obtained also from Ceylon, Burmah, China, the Malay Archipelago, etc. The great centre of the lac industry in India is the Province of Bengal, the capital of which, Calcutta, is a great emporium for lac in all its forms. In the Bengal districts it is collected about twice a year, from the middle of October to January and from the middle of May to the middle of July. In the Scinde State it is obtained chiefly from the forests surrounding Hyderabad, where it is found on the babool tree, *Acacia arabica;* the lac is gathered from October to April. It is rather noteworthy that the insects do not attack the trees while the latter are in full growth, but only when they begin to wither. Hyderabad is celebrated for its lacquer ware, and the lac which is obtained is used almost entirely for this in the locality. Assam is a great lac country and the lac is collected in large quantities; some is used locally, but most is sent to Calcutta for export.

Lac comes into commerce as—

1. Stick lac.
2. Seed lac.
3. Shellac.
4. Button lac.
5. Garnet lac.

Another lac product is lac dye.

1. **Stick Lac.**—This is the crude material as it comes from the tree, and consists of bits of the twig or bark incrusted with the lac. In this form it is mostly sent into the great centres of the trade from the forests in which it is collected for manufacture into the refined lac products. A small quantity is imported into this country, but it is obvious that the payment of freight charges on a lot of useless woody matter is a drawback.

The process of refining the stick lac into the other lac products is a very simple matter and is often carried on in primitive ways; although of late more attention has been paid by the large lac merchants to improved processes of treatment.

The first operation consists in separating the lac from the woody matter on which it is found; this is done by laying the stick lac on a table and passing a heavy roller over it; this breaks the lac, and the wood is then picked out by hand or separated by sieving. The wood is thrown away or used as fuel. The pieces of lac are collected and placed in large tubs with warm water, the workmen treading the material in the tubs; this operation extracts from the lac the colouring matter it contains, which passes into solution; the treatment with water is several times repeated until the wash waters are clear. The water used in the first washing containing the colouring matter is evaporated down and the colouring matter thereby recovered; it is sold under the name of lac dye (see *Lac Dye*). The lac which is left behind is known as *seed lac*.

2. **Seed lac.**—This is the partly manufactured lac obtained in the first operation of preparing the crude lac. It occurs in the form of small grains or pieces; hence its name of *seed lac*. It is scarcely an article of commerce, although sold to a small extent; it is further treated to manufacture the commercial varieties of lac.

3. **Shellac.**—This is the principal commercial variety of lac and is prepared and sold in large quantities. It is prepared from the seed lac by drying the latter product; the dried lac is then placed in large bags made of cotton cloth of a medium texture. The bag of lac is held by two men in front of a large fire. The heat of the fire soon melts the lac, which flows out of the bag, the men assisting the flow by twisting the bag so as to squeeze out the contents; the molten lac drops into a trough placed in front of the fire. A cylinder of wood, or of wood covered with brass, is mounted on axles, so as to be in a slightly inclined position; an operator dips a ladle into the trough of molten lac and pours it over the cylinder, while an assistant spreads the lac over the surface of the cylinder with a plantain leaf. It rapidly sets, when it is stripped off the cylinder by means of a knife and then forms the shellac of commerce. Sometimes this method of working is modified in various districts. The crude seed lac may be subjected to a further purifying process by boiling it with a little alkali, so as to remove the last traces of colouring matter from it, thereby yielding a better and paler quality of shellac.

The best quality of shellac is that known as *orange* shellac, which is of a pale brownish-orange colour, quite clear and transparent; but many qualities are recognised in commerce, distinguished from one another by their colour, transparency, uniformity of grade and freedom from dirt and grit.

4. **Button Lac.**—This variety of lac is only different from shellac in form. Instead of being made into thin sheets the melted seed lac is poured on to plates of stone or metal in such a way that it sets into roundish pieces, which, owing to their thickness, appear of a brownish colour. Generally button lac is not made of such a fine quality of lac as is orange shellac, but for common purposes it answers equally well.

5. **Garnet Lac.**—This lac occurs in thick flat pieces of a dark colour and contains more colouring matter than either shellac or button lac. It is serviceable for making dark-coloured varnishes, and in many other cases may be substituted for shellac.

Lac in all its forms possesses the following properties: It is incompletely, or only partially, soluble in alcohol or methylated spirit, forming a turbid orange-brown solution, which is largely used as a varnish or polish for furniture and woodwork in general. It is soluble in amyl alcohol (fusel oil). It is only partially soluble in ether, chloroform and turpentine; while it is insoluble in petroleum spirit. It is soluble in solutions of caustic potash and of caustic soda, in borax and in ammonia. Such solutions are frequently prepared and used as varnishes and as dressings for leather. One point of interest in connection with the solubility of shellac in alkaline solutions appears to be that the alkali first attacks the colouring matter of the resin, dissolving it out and leaving the lac free from colour. This may be taken advantage of in preparing white shellac. When chlorine is passed through alkaline solutions of lac the resin is thrown down free from colour.

Lac has a specific gravity of 1·113 to 1·214, the darker grades usually being the heavier. It softens when heated in boiling water and melts at a slightly higher temperature.

Crude stick lac which has been freed from the woody matter contains 66·67 per cent. of resinous matter, 6 per cent. of wax (which consists chiefly of myricyl melissate, $C_{15}H_{31}COOC_{29}H_{59}$, with some free myricyl alcohol, $C_{15}H_{31}OH$) 6 per cent. of gluten, and 10·8 per cent. of colouring matter. The process of preparing lac eliminates the colouring matter and gluten, leaving the wax and resinous matter. Five distinct resins have been extracted from commercial lac: (1) a resin soluble in alcohol and ether; (2) a resin soluble in alcohol, but not in ether; (3) a resin slightly soluble in alcohol; (4) a crystallisable resin; and (5) an uncrystallisable resin. These resins constitute about 90 per cent. of the lac, the remaining 10 per cent. consisting of (6) a fatty matter, (7) wax, (8) gum, and (9) colouring matter.

Lac is chiefly used in making spirit varnishes of all kinds, sealing wax and cements; but it has various other uses.

**Bleached Shellac.**—A white or bleached shellac is prepared and used in the making of white varnishes. This so-called *bleached* shellac is prepared in several ways. One method is to boil ordinary shellac in a weak solution of carbonate of potash until it is dissolved; then to pass chlorine gas through the solution. When the lac is thrown down free from colour the resin is collected, washed with warm water, melted over water, and, by working with the hands, made into the form of more or less twisted cylindrical pieces having a marked fibrous structure. Another method which is followed is to treat the shellac with a weak solution of potash at such a temperature that it is softened, and then to work the lac with the hands until it has lost its colour and has acquired the fibrous appearance usual with bleached shellac. White shellac is always sold in the form of long cylindrical pieces having a fibrous, satiny appearance. It is used in making white varnishes and for other purposes where a white shellac would be useful. Its properties are the same as the ordinary shellac; but it gradually deteriorates, becoming very brittle and insoluble in alcohol and in alkaline solutions. Care should be taken, therefore, to use bleached shellac, which has only recently been prepared. When fresh, white shellac is rather damp; it therefore requires drying before it can be used in making spirit varnishes.

**LAC DYE.**—This product is the colouring matter of lac (see above), and is obtained by boiling the crude stick lac with water, which dissolves out the colour, and then evaporating the solution to dryness. In its dyeing properties the lac dye resembles cochineal, but gives somewhat duller and rather more fugitive shades. Prior to the introduction of the coal-tar colours it was largely used in dyeing, but it has now become practically obsolete for that purpose in England.

**LAKES.**—The lakes are a class of pigments of ancient origin which are much employed, especially by artists; but their use among painters, paper stainers and others has much developed of late years. The origin of these colours is usually given as follows: The ancient Italian dyers made extensive use of such dyes as cochineal in combination with tin and alumina for the purpose of developing and fixing the colour on their materials. On the surface of their dye-baths a coloured scum accumulated. This was collected and sold to artists under the name of lacca. It was not long before methods of preparing these coloured bodies from the dyes themselves (without having recourse to the dyer's vat) were found out, and all such pigments were known generally as laccae, from which word our English *lakes* is derived by easy transitions.

The typical lake is carmine, which is prepared from cochineal by means of alum. When the composition of this pigment is examined it is found to consist of a combination of the colouring principle of the cochineal (carminic acid) with alumina and lime. This leads us to a general definition of lakes as compounds of organic colouring matters with metallic oxides. Generally speaking the colouring principles of the natural organic colouring matters or dyes, such as cochineal, logwood, Brazil wood, fustic, Persian berries, etc., possess a more or less acid character. At all events they are capable of combining with the basic oxides of the metals to form coloured compounds, those of the alkalies being soluble in water, while those formed with alumina, lead, tin and other metals are insoluble in water, and hence are always formed as precipitates when a solution of a salt of the metal is added to one of the colouring matter. These precipitates are generally known as *colour lakes*. The dying of textile fibres with the natural colouring matters depends upon their formation on the fibre, while they form the basis of the artist's lakes. Carmine is a pure colour lake. On the other hand, crimson lake, Florentine lake, Dutch pink and rose pink contain an excess of the metallic base, *i.e.*, more than sufficient to combine with the colouring matter in them.

Of late years the coal-tar colours have been pressed into service for the preparation of lake pigments. Many of these have the property of forming colour lakes, *i.e.*, insoluble coloured bodies with metallic oxides. Such are Alizarine, Coeruline, Alizarine yellow, Alizarine blue, Galloflavine, Gambine, etc. With these are perfectly comparable in their chemical composition the colour lakes derived from the natural dyestuffs, such as cochineal or madder. Again, other coal-tar colours, such as the Eosines, Azo scarlets, Croceir scarlets, have the property of giving colour lakes with meta salts. These also are used in preparing lake pigments. Then there are the basic coal-tar colours, like Magenta, Brilliant green, Auramine, Victoria blue, etc., which form colour lakes with tannic acid. These also have been pressed into service. With the coal-tar colours it has, however, been found impracticable to make a pure lake, *i.e.*, one consisting of the colour lake itself, in the main resembling carmine, for various reasons, partly that the full beauty of the colour cannot thereby in all cases be developed, partly because such pure colour lakes are too expensive. Therefore in using the coal-tar colours for making lake pigments it is customary to add a quantity of barytes or some other white pigment, which constitute what is commonly called the *base* of the lake, although in strictness the term base ought to be reserved for the actual precipitant of the colouring matter. The white pigment, or so-called base, is really a *diluent*.

Lakes in general are brilliant in colour, but are not remarkable for permanence. Those made from madder, alizarine and the alizarine dyes in general, are fairly permanent; but those prepared from other dyes are not. They are usually strong in colouring power, but deficient in body or opacity. This more especially applies to the older lakes. Many of the modern lakes made from coal-tar colours possess a fair body and good covering powers, due to the white pigment which they contain.

The most common lakes, such as *Carmine*, *Crimson Lake*, *Dutch Pink*, *Vermilionettes*, etc., will be found described under their respective heads. See Tennison's *Lake Pigments*, and Bersch's *Mineral and Lake Pigments*.

**LAMP BLACK** is one of the most valuable of the black pigments; it consists, essentially, of carbon in a very fine state of division, and is prepared by burning oils of various kinds in a lamp burner, or by other means, in such a way that incomplete combustion takes place and a large volume of smoke is produced; this smoke consists of unburnt particles of carbon and is collected in a specially constructed system of flues. There are some differences in the quality of lamp blacks, as heavy and light lamp black, which varieties depend upon the place in the flues from which the black is collected—that nearest the burning oil being heavier than that farthest away (see *Vegetable Black*). Sometimes the heavy grades of lamp black contain traces of unburnt oil; when this becomes excessive in amount it shows a defective method of working in the preparation of the black; the presence of such oil may lead to spontaneous combustion of the lamp black, while it impedes the drying of the paint made from the black. The following are two analyses of lamp black made by the author:—

| | Per Cent. | Per Cent. |
|---|---|---|
| Carbon . . . . | 93·5 | 94·99 |
| Water . . . . | 4·4 | 1·81 |
| Ash . . . . . | 2·1 | 3·20 |

As a pigment lamp black is perfectly permanent and may be mixed with all other pigments without producing any change. It mixes with oil, water and all other vehicles. Black paint made with lamp black is rather slow of drying, owing to the fact that the pigment does not exert any drying action on the oil; possibly it may even have a retarding influence.

Lamp black is sometimes ground up with turpentine (of which it takes up about 55 per cent. of its weight) into a paste, and sold in that form.

Lamp black may be analysed in the following manner: Weigh into a platinum crucible 2 grammes of the black and place it in a hot air oven at about 105° to 110° C. until repeated weighings show that it has ceased to lose weight; the loss gives the amount of moisture in the sample. Next place the crucible and its contents over a Bunsen burner and heat to a bright red heat until all the carbonaceous matter is burnt off and only a grey ash is left behind; after allowing the crucible to cool, it is weighed and the amount of ash ascertained. It should not amount to more than 2 per cent.

In case the sample shows signs of containing unburnt oil, the amount of this may be ascertained by weighing out 10 grammes into a filter paper and placing it in a Soxhlett fat extractor, extracting the oil by means of petroleum ether; on evaporation of the latter the oil will be left behind and may be weighed. Lamp blacks with a large proportion of oil in them are objectionable on account, first, of liability to spontaneous combustion and, second, to the oil retarding their drying when made into paint.

**LEAD** is a most important metal to the painter, as also to the user of pigments and colouring matters, as it forms the basis of a large number of pigment colours, white lead, red lead, chrome yellow, Derby red, etc., and enters into the composition of a large number of products used in painting, decorating, pottery manufacture, etc. Lead is a heavy metal, its specific gravity being 11·24. It has a silver grey colour, and is very bright when fresh, but becomes dull on exposure to the air, owing to the formation of a thin film of oxide. It is soft and may be easily cut with a knife. It melts at 330° to 335° C. When melted it readily absorbs oxygen and becomes converted, first, into a monoxide and, finally, into red lead (see *Red Lead*). It is attacked by acids, being dissolved by dilute nitric and acetic acids in the cold; dilute sulphuric acid has no action on it, but strong sulphuric acid dissolves it, with the formation of lead sulphate. Hydrochloric acid has little action in the cold, but dissolves it on heating.

Lead is largely used in sanitary work in making water pipes and gas pipes, for roofing purposes, for making water channels, etc. It is also largely used in chemical manufacture, especially in the construction of sulphuric acid chambers, and as a lining for dye vats, tanks, etc.

Lead combines with oxygen to form three oxides: the monoxide $PbO$, or litharge (see *Litharge*); the dioxide $PbO_2$; and the tetroxide $Pb_3O_4$, or red lead (see *Red Lead*). Lead forms one series of salts only, in which it acts as a dyad element. The most important salts are the acetate $Pb2C_2H_3O_2$; the nitrate $Pb2NO_3$; the carbonate $PbCO_3$; the sulphate $PbSO_4$; the chromate $PbCrO_4$; the sulphide $PbS$; all of which are described below.

The distinguishing tests for lead are:—

Hydrochloric acid gives a white precipitate of lead chloride soluble in boiling water, from which solution it crystallises out on cooling.

Sulphuretted hydrogen gives a black precipitate of lead sulphide from acid solutions. This is converted into lead sulphate by nitric acid, but is not affected by hydrochloric acid.

Potassium chromate gives, from neutral or acetic acid solutions, a bright yellow precipitate of lead chromate. This precipitate is soluble in nitric acid and in caustic soda.

Lead is nearly always quantitatively estimated as sulphate. The substance is dissolved in water or nitric or acetic acid as may be required. To the solution is added an equal volume of alcohol and then sufficient dilute sulphuric acid to throw down all the lead; the precipitate is then filtered off, well washed with water and dried; the dry mass is now transferred as completely as possible to a weighed porcelain crucible, while the filter paper is burnt on the lid of the crucible; the ashes are first treated with a drop of nitric acid, then a drop of sulphuric acid, then heated to expel excess of acid; finally, they are transferred to the main portion of the lead sulphate in the crucible and the whole is now heated for some time over the Bunsen burner until the precipitate is thoroughly dry, when it is allowed to cool and the crucible and its contents weighed. The weight of the empty crucible and that of the filter ash is deducted from the total weight; the difference is the weight of the lead sulphate obtained. From this weight that of the lead in the original sample may be calculated by multiplying by 0·683, or that of lead oxide by multiplying by 0·736.

**LEAD ACETATE.**—See *Acetate of Lead*.

**LEAD BLACK.**—Under this name has been sold the sulphide produced by acting on a lead salt with alkaline sulphides or sulphuretted hydrogen. As a pigment it is almost useless, as, on exposure to the air, it gradually undergoes oxidation.

**LEAD BORATE.**—This substance is produced by mixing solutions of lead acetate and borax together, when it is thrown down as a precipitate. This is collected, well washed with water and carefully dried. It is largely used as a drier in boiling oil, as also making paints and varnishes. It is found that it does not lead to the discolouration of the oil as is the case with red lead or litharge. Its drying properties are fully equal to those of litharge.

**LEAD CARBONATE.**—The normal carbonate, $PbCO_3$, occurs naturally (as the mineral cerusite) in small quantities in various places. It is not used for any particular purpose. When solutions of alkaline carbonates are added to solutions of lead salts, or when a current of carbonic acid gas is passed through a solution of basic acetate of lead, precipitates of basic carbonates are obtained. These form the basis of the pigment, white lead, which has a composition approximating to the formula, $2PbCO_3, PbH_2O_2$. (See *White Lead.*) Lead carbonate, whether normal or basic, is soluble in dilute nitric or acetic acids with effervescence, owing to the evolution of carbonic acid gas. The solution is colourless and gives all the tests for lead, *viz.*, yellow precipitates with potassium chromate and potassium iodide, white precipitates with hydrochloric acid and sulphuric acid, and black precipitate with sulphuretted hydrogen.

**LEAD CHROMATE.**—This lead compound forms the base of the commercial chrome yellows, oranges and scarlets. Lead and chromic acid are capable of combining together in various proportions, forming normal and basic salts. The normal lead chromate, $PbCrO_4$, is obtained on adding a solution of the normal potassium chromate or of potassium bichromate to one of lead acetate or nitrate. It forms an amorphous powder of a bright yellow colour. When strongly heated it decomposes, giving off oxygen and leaving a residue of chromium oxide and basic chromate of lead, the composition of which varies with the degree of heat employed. When boiled with hydrochloric acid chlorine is evolved and the chromate is dissolved, with the formation of the chlorides of lead and chromium, the solution having a green colour. When boiled with strong sulphuric acid oxygen is evolved and a white insoluble residue of lead sulphate obtained, while chromium sulphate remains in solution. It is soluble in caustic soda solution. The first action of the alkali is to abstract a portion of the chromic acid, thereby giving rise to the formation of a basic chromate of a red colour. Then, if the alkali is in excess, it dissolves this. On adding an acid to the alkaline solution the normal chromate is again thrown down. Normal lead chromate forms the base of the chrome yellows. (See *Chrome Yellow.*) A basic chromate of lead, having the formula, $PbCrO_4PbO$, is obtained by boiling lead chromate with the equivalent quantity of caustic soda; by boiling white lead with potassium chromate; or by melting potassium nitrate and throwing chrome yellow into the melted mass. The second of these methods is used on the large scale for making Derby red. The basic chromate of lead is a fine red pigment prepared and sold under a variety of names, Derby red, Persian red, American vermilion, etc. (See *Derby Red.*) In its chemical properties it resembles the normal chromate. Some basic chromates having compositions slightly different are found in various minerals.

**LEAD NITRATE.**—This important lead salt is obtained by dissolving lead or litharge in nitric acid and crystallising out the lead nitrate formed. Lead nitrate occurs as pearly white, flat crystals, having the following composition: 67·32 per cent. of lead oxide and 32·68 per cent. of nitric anhydride. The formula, therefore, is $Pb2NO_3$. It is soluble in water and dilute nitric acid, but not in strong nitric acid. When heated it decomposes, giving off oxygen and nitric peroxide and leaving a residue of lead oxide. It is used in preparing chrome yellows and oranges and for other purposes. It gives the usual tests for lead. When heated with sulphuric acid it gives off nitric acid. A sample of lead nitrate should be readily and completely soluble in water. The lead it contains may be estimated by precipitation with sulphuric acid as described above (see *Lead*); while the nitric acid it contains may be estimated by distilling 2 grammes with sulphuric acid nearly to dryness, adding water to the residue in the retort, repeating the distillation, collecting the distillates and titrating them with standard caustic soda, using phenol-phthalein as an indicator. The number of cubic centimetres of standard alkali used multiplied by 0·063 gives the quantity of nitric acid obtained.

**LEAD OXIDES.**—Lead and oxygen combine together to form three oxides as follows: The monoxide, PbO or litharge (see *Litharge*); the dioxide, $PbO_2$, or brown oxide; and the tetroxide, $Pb_3O_4$, or red lead (see *Red Lead*). Of these oxides the first and third are valuable commercial products, and are described under their respective names. The monoxide is a basic oxide. When acted on by acids it forms the various salts of lead. Thus, with acetic acid it forms the acetate, with nitric acid the nitrate, with sulphuric acid the sulphate, and so on. The second oxide, lead dioxide, $PbO_2$, is obtained by treating red lead with dilute nitric acid and collecting the residue of brown oxide of lead. It is a peroxide. When heated with hydrochloric acid it gives rise to the evolution of chlorine and the formation of lead chloride. Sulphuric acid decomposes it into lead sulphate with the evolution of oxygen. Heating with strong nitric or acetic acids gradually dissolves it, with the formation of lead nitrate or lead acetate respectively. It has no commercial importance. The third oxide is red lead. It is generally regarded as a compound of the mon- and dioxides of lead, inasmuch as when treated with dilute acids it yields the brown oxide as an insoluble residue, while there is found in solution a salt of lead.

**LEAD SULPHATE.**—This salt of lead has the formula $PbSO_4$. It is obtained when sulphuric acid, or a soluble sulphate, is added to a solution of a lead salt, the sulphate being thrown down as a white precipitate. It is also formed when galena (lead sulphide) is heated in a current of air, and when lead compounds are heated with sulphuric acid. It is a white powder, insoluble in water, slightly soluble in acid solutions, but more soluble in solutions of ammonium sulphate. When boiled with strong hydrochloric acid it dissolves; as the solution cools crystals of lead chloride separate out. It is insoluble in dilute nitric acid. Strong sulphuric acid dissolves it, but dilution with water again precipitates it. Heat has little effect on it. When boiled with solutions of caustic soda it is dissolved, if excess of alkali be employed. The first action is to convert the sulphate into hydroxide, a reaction which goes on in quantitative proportions. When boiled with solutions of alkaline carbonates it is partially converted into lead carbonate.

Lead sulphate forms the base of several white pigments, which are often sold under such names as non-poisonous white lead, innocuous white lead, patent white lead, etc.

Lead sulphate is distinguished by its insolubility in dilute nitric acid, by its dissolving in hydrochloric acid, the solution giving white crystals of lead chloride on cooling and a white precipitate of barium chloride being added, this precipitate of barium sulphate being insoluble on boiling.

The presence of lead sulphate in pigments may be detected by treating them with dilute nitric acid and examining the insoluble residue with hydrochloric acid as just described. If there be any barytes in the pigment it will be left undissolved by the hydrochloric acid.

**LEAD SULPHIDE.**—This compound of lead is found in great abundance in nature as the mineral galena. Its composition is shown by the formula PbS. It is the most important ore of lead. It is obtained in the wet way by adding a solution of an alkaline chloride to one of a lead salt or by passing a current of sulphuretted hydrogen gas through a solution of lead; in both cases it is obtained as a black precipitate. Lead sulphide is insoluble in water and in strong hydrochloric acid; nitric acid oxidises it to sulphate; when heated it melts, and in a strong current of air is oxidised to sulphate. Lead sulphide has been sold as a pigment under the name of *lead black*, but it is of no practical importance.

**LEMON CHROME.**—This is the name given to the palest chrome yellows. The best lemon chromes are mixtures of lead chromate with lead sulphate in various proportions; others contain lead chromate, barytes and sometimes gypsum. Its properties as a pigment and the methods of testing and analysing are the same as for chrome yellow (see *Chrome Yellow*).

**LIME or QUICKLIME** is the oxide of the metal calcium, having the chemical formula $CaO$. It is prepared by heating limestone or chalk (the natural forms of calcium carbonate) in kilns. Its principal property is that when treated with water it combines with it, with the evolution of much heat and the formation of calcium hydroxide, $CaH_2O_3$; this operation is known as *slaking* and the product is known as *slaked lime*. Lime is also known as *caustic lime*, on account of its burning effect on the skin and animal tissues generally. On exposure to the air quicklime absorbs moisture and crumbles to a fine white powder, *air slaked lime*, which has not the same powerful properties as the slaked lime prepared with water. It also absorbs carbonic acid from the air, passing into calcium carbonate; consequently, it is important not to expose lime or slaked lime to the air. Lime is used in the preparation of mortars, cements, and concrete for building purposes; in the preparation of lime blue (see *Lime Blue*), chrome orange and other pigments; in the manufacture of caustic soda and caustic potash; for colouring walls, etc.

Lime should be used fresh, as the carbonate of lime formed in old lime detracts from its value. It ought to be well burnt and strong; when mixed with water in sufficient amount it ought to form a smooth, buttery mass, free from gritty particles. Such a mass of slaked lime, if kept covered with water, will keep good for some time, but lime which has been badly slaked will not keep. Lime, or rather calcium hydroxide, is slightly soluble in water, such a solution forming what is known as *lime water*, while *milk of lime* is the name given to a mixture of undissolved lime and water of about the consistency and colour of milk. A gallon of lime water contains 89·5 grains of calcium oxide or 118·5 grains of calcium hydroxide.

### AMOUNT OF LIME IN MILK OF LIME OF DIFFERENT SPECIFIC GRAVITIES.

| Specific Gravity. | Grammes CaO in one Litre. | Specific Gravity. | Grammes CaO in one Litre. | Specific Gravity. | Grammes CaO in one Litre. |
|---|---|---|---|---|---|
| 1·01 | 11·7 | 1·10 | 126·0 | 1·18 | 229·0 |
| 1·02 | 24·4 | 1·11 | 138·0 | 1·19 | 242·0 |
| 1·03 | 37·1 | 1·12 | 152·0 | 1·20 | 255·0 |
| 1·04 | 49·8 | 1·13 | 164·0 | 1·21 | 268·0 |
| 1·05 | 62·5 | 1·14 | 177·0 | 1·22 | 281·0 |
| 1·06 | 75·2 | 1·15 | 190·0 | 1·23 | 294·0 |
| 1·07 | 87·9 | 1·16 | 203·0 | 1·24 | 307·0 |
| 1·08 | 100·0 | 1·17 | 216·0 | 1·25 | 321·0 |
| 1·09 | 113·0 | | | | |

**LIME BLUE.**—This name was given to a copper blue prepared from copper sulphate by precipitation with lime, usually in the presence of ammonium chloride. Essentially it consists of a mixture of hydroxide of copper with calcium sulphate. It was once used to a very considerable extent in distemper work with lime and whiting, as it was then the only blue known which would resist the action of lime and was cheap.

It has now become nearly obsolete, having been replaced by artificial ultramarine, which is cheaper and better in every respect. Lime blue is a pale blue pigment of no great depth of colour or body. It is fairly stable when exposed to light and air. Sulphuretted hydrogen and sulphurous bodies turn it black, owing to the formation of the sulphide of copper. Heat also turns it black, the hydroxide of copper losing its water and becoming changed into the oxide. Acids destroy the colour, dissolving out the copper and leaving some of the calcium sulphate undissolved. Lime blue may be distinguished from other blues by the following reactions. Heated, it turns black; treated with acids, it partially dissolves—a faint blue solution and a white residue being obtained. The blue solution changes to a deep blue on adding excess of copper—this reaction being very characteristic of copper. On boiling the solution and adding caustic soda a black precipitate of copper oxide will be obtained. The solution will also give a white precipitate on addition of barium chloride, indicating the presence of sulphate; and a white precipitate on the addition of ammonium and ammonium oxalate, indicating the presence of lime.

**LIMONITE** is the mineralogical name of the hydrated oxide of iron, which occurs in a variety of forms, crystalline and amorphous. The colour is usually brownish. The purest limonite has a composition corresponding to the formula $2Fe_2O_3, 3H_2O$; it contains 85·6 per cent. of ferric oxide and 14·4 per cent. of water. Limonite is the colour constituent of ochres, siennas, umbers and other natural yellow or brown earthy pigments; in these it is associated with clay, barytes, gypsum, etc., and then forms very useful pigments, which are found widely distributed in nature (see *Ochres*, *Siennas*, *Umbers*). Limonite is soft, readily soluble in acids, forming yellow solutions, which give all the characteristic tests for iron. On being heated, it parts with its water and leaves a red residue of the ferric oxide; this change of colour from brown to red is eminently characteristic of all those pigments into whose composition limonite enters.

**LINSEED OIL.**—This oil, the product of the seeds of the flax plant, *Linum ussitatissimum*, is the most important of all oils to the painter. Its chief and most distinguishing character is that on exposure to the air in thin films it dries to a hard firm mass and thus is capable of acting as a binding material to pigments when used as paints. It is obtained from the seed by hydraulic pressure. The process is fully described in the author's *Manual of Painter's Oils and Colours.*

Linseed oil is sold in two forms, "Raw" and "Boiled".

**Raw Linseed Oil.**—*Raw linseed oil* is the oil as it is obtained from the presses, after having undergone a certain amount of purification to free it from insoluble particles, water, etc. The better qualities of the oil are occasionally subjected to a refining process for the purpose of extracting some of the colouring matter contained in the crude oil, and all the mucilage and other impurities; this purified oil is then sold under the name of *refined linseed oil.*

Raw linseed oil is a yellowish oil, usually having a brown hue which is strongest in the crude oils, less so in the commercial "raw" oils and least in the "refined" oils; this colour is due to the presence of chlorophyll. The odour and taste of linseed oil are characteristic. It is perfectly clear and limpid at all ordinary temperatures, but when subjected to a moderate degree of cold it becomes slightly more viscous, and at temperatures below – 27° C. it solidifies.

The specific gravity of linseed oil varies a little; at 15° C. (60° F.) it averages 0·935, but ranges from 0·931 to 0·937.

Baltic linseed oil is usually the heaviest, while East Indian and Black Sea oil have about the same specific gravity. The author obtained the following figures: Baltic oil, 0·9378; Black Sea oil, 0·9326; East Indian oil, 0·9339. At 100° C. (212° F.) linseed oil usually has a specific gravity of 0·801.

It is soluble in about 40 times its volume of alcohol at the ordinary temperature and in about 5 times its volume of boiling alcohol. It readily dissolves in petroleum ether, ether, shale naphtha, turpentine, rosin spirit, chloroform and similar solvents.

Sulphuric acid has a strong action on linseed oil, giving rise to a considerable elevation of temperature. It generally reaches about 120° C., but varies with different samples of oil. Thus the author has obtained the following figures: With Baltic linseed oil, 120° C.; with Black Sea oil, 114° C.; and with East India oil, 110° C. Nitric acid also exerts a strong action on linseed oil, but the degree of action depends upon the strength of the acid. A moderately strong acid converts the oil into a viscid mass which is insoluble in petroleum spirit. Nitrous acid does not give a solid elaidin with linseed oil.

On gently warming linseed oil with glacial acetic acid the oil dissolves. On cooling the oil is deposited. The first deposition which shows itself is as a turbidity in the liquid. This occurs at from 36° to 47° C., according to the quality of the oil and the strength of the acid. This property of linseed oil constitutes a useful test for the purity of the oil, as, if adulterated with mineral oil or rape oil, the whole of the oil is not soluble in the glacial acetic acid, or the turbidity forms at a much higher temperature.

Linseed oil combines readily with bromine or iodine, and takes up larger proportions of these bodies than any other oil. There are slight differences between the various kinds of linseed oil as to the amounts of bromine or of iodine they will absorb. The average is 156 per cent. of iodine and 98 per cent. of bromine. That is, 100 parts of linseed oil will take up 156 parts of iodine or 98 parts of bromine. It may be laid down as a rule that the better the quality of the oil the more of these bodies will it take up.

The property which gives linseed oil its value to the painter is that it combines readily with oxygen, forming a hard, dry, resinous substance. This it does most readily when exposed as a thin film (the condition when employed in painting) to the air. In this property of absorbing oxygen linseed oil is markedly distinguished from other oils. W. Fox, *Oil and Colourman's Journal*, 1884, p. 234, gives the following table showing the number of cubic centimetres of oxygen absorbed by 1 gramme of various oils :—

| | |
|---|---|
| Baltic linseed oil | 191 |
| Black Sea linseed oil | 186 |
| East Indian (Calcutta) oil | 126 |
| East Indian (Bombay) oil | 130 |
| American linseed oil | 156 |
| Brown rape oil | 20 |
| Colza oil | 17·6 |
| Olive oil | 8·2 |
| Cotton seed oil | 24·6 |

Evidently the quality of linseed oil depends very much upon its oxygen-absorbing powers. Thus Baltic oil, recognised as the best kind of linseed oil, possesses drying properties superior to those of any other, while Indian linseed oil is ranked the lowest. From the above table we see that while Baltic oil takes up the most oxygen East Indian oil takes up the least.

This difference between the qualities of linseed oils from different localities must be due to the difference in the character of the climate of the country in which the seed was grown—the rule, apparently, being that the colder the climate the better is the oil. This is borne out by the difference in the oils from the Baltic and the Black Sea. The seed from which the former oil has been extracted will have been grown in places much farther North than where the Black Sea seed was grown, and, therefore, presumably much colder. India is a much hotter country than Russia; hence, applying the rule, we find that Indian oil has poorer qualities than either of the two oils previously noted.

Oxidised oil is a product largely used in the manufacture of linoleums and floor oilcloths. It is prepared by hanging sheets of canvas in an airy room and pouring over them raw linseed oil and allowing the film of oil which adheres to the canvas to dry. Then another film of oil is poured over the canvas, which is also allowed to dry. These operations are repeated until a thick coating of oxidised oil is formed on the canvas. It may be mentioned that the oxidation of the oil appears to extend to the canvas as the latter becomes more or less tender and rotten. A very thick layer of oxidised oil cannot, therefore, be formed. The oxidised oil is heavier than the raw oil used, the increase in weight being about 10 per cent.; but the actual amount of oxygen absorbed must be more than this, inasmuch as some volatile products are formed.

The solid and elastic product produced has been named by Mulder *linoxyn*, and represented by the formula, $C_{32}H_{54}O_{11}$. It is quite insoluble in water and alcohol. Ether and chloroform partially dissolve it, showing that it is probably a compound of two different bodies, one soluble the other not. When boiled with caustic potash it undergoes saponification, forming a red-coloured soap. Oxidised linseed oil is slightly heavier than water. When oxidised oil is exposed to the air for some considerable time it decomposes and becomes soft and sticky. Ultimately it becomes fluid, soluble in alcohol, and partially soluble in water. According to Reid, *Journal Society Chemical Industry*, November, 1894, this explains why paint lasts longer in sheltered places than in those where it is exposed to wind, rain and other weather influences.

When raw linseed oil is boiled with caustic potash or caustic soda it undergoes saponification, glycerine being formed at the same time. From 18·7 to 19·5 per cent. of caustic potash, or from 13·4 to 15 per cent. of caustic soda, are required for complete saponification ; while from 9·4 to 10 per cent. of glycerine is set free. When the soaps so formed are treated with dilute sulphuric acid they are decomposed and the fatty acids of the linseed oil separated. These acids have a specific gravity, at 15° C., of 0·924 to 0·927 ; and, at 100° C., of 0·861 to 0·864. They are solid acids, melting at 22° C. to 25° C., and solidifying at from 20° C. to 18° C. They are insoluble in water, but soluble in alcohol, ether and other solvents. Their combining equivalent is about 306, which points to the presence of acids of high molecular weight. To the mixture of acids from linseed oil thus obtained the name of *linoleic* acid is given. Linoleic acid is rather prone to oxidation, absorbing oxygen rapidly. It is, therefore, rather difficult to prepare these acids in a state of purity.

To linoleic acid has been ascribed the formula, $C_{16}H_{32}O_2$. Recent researches have shown that this cannot be correct. In the first place, this formula only corresponds to a molecular weight of 252, while the equivalent of the acids of linseed oil is always above 300. If linoleic acid contained 16 atoms of carbon it would be isologous with palmitic acid, which also contains 16 atoms of carbon, and should, on being hydrogenised, yield that acid ; while, as a matter of fact, it does not yield palmitic acid but stearic acid, which has 18 atoms of carbon. Then, again, linoleic acid when treated with an alkaline solution of potassium permanganate yields an hydroxy acid, known as sativic acid, having the formula $C_{18}H_{32}O_2(OH)$. According to the researches of Hazura, linseed oil contains two acids. One is named linolic acid and is a tetrolic acid, having the formula $C_{18}H_{32}O_2$, capable of combining with 4 atoms of bromide and forming sativic acid when oxidised by an alkaline solution of potassium permanganate. The other acid is linolenic acid. This has the composition, $C_{18}H_{30}O_2$, and belongs to a series of fatty acids of the general formula, $C_nH_{2n} - 6O_2$, a series of acids only recently discovered. This acid has the high iodine value of 245, owing to the fact that it will combine with 6 atoms of iodine, or the same number of atoms of bromine. These researches of Hazura require confirmation, particularly as to the existence of the last acid. The equivalents of these acids would indicate that linseed oil contains an acid with more than 18 atoms of carbon.

The purity of a sample of linseed oil may be ascertained by the application of the following tests:—

*Specific Gravity.*—This can be ascertained by any of the well-known means. The gravity should exceed 0·930. Any sample having a gravity below that may be regarded with suspicion, as also any sample with a gravity higher than 0·939.

*Flash Point.*—Place a little of the oil in a small porcelain basin and heat it with a Bunsen flame. The rate of heating should be slow. In the oil support a 600° F. thermometer. When the temperature reaches about 300° vapour will be noticed. The temperature at which this occurs ought to be noted. Now, by means of a taper with a small flame (or, better, a blowpipe attached to a gas jet and having a flame about the size of a pea), endeavour to set light to the vapour ascending from the oil, taking care that the testing jet does not touch the surface of the hot oil. Sooner or later a blue flame will appear to shoot across the surface of the oil. The temperature at which this occurs is called the *flashing point* of the oil. In the case of pure linseed oil it will be between 450° F. and 500° F. A flash point of below 400° F. may indicate addition of mineral or hydrocarbon oil, while a flash point of less than 350° F. may indicate the addition of rosin oil.

*Proportion of Mineral or Rosin Oil.*—If the specific gravity and the flash point have given some indication of the presence of mineral oil or of rosin oil, the following process may be adopted for determining its amount. Weigh out 20 grammes of the oil to be tested, add a quantity of a solution of caustic soda (or, better, of caustic potash) in water and a few drops of methylated spirit; boil well for about an hour, or until it is considered that the linseed oil has been thoroughly saponified; then allow the mass to cool. When cold, add about an equal volume of petroleum ether, stir the mixture well, and transfer it to a separating funnel, adding a quantity of warm, but not hot, water. On allowing it to rest, the petroleum ether will rise above the aqueous liquor, and carry with it any mineral or rosin oil that may be present. The lower aqueous layer is now run off, fresh warm water is poured into the funnel, the whole well shaken and again allowed to rest; the aqueous layer is then run off, and the washing with warm water repeated two or three times. The ether layer is next run into a weighed glass beaker, the ether evaporated off on a water bath and the residual oil weighed. With care, fairly accurate results can be obtained by this method. The residual mineral oil may be examined to ascertain whether it be a mineral or hydrocarbon oil or be rosin oil; the specific gravity will, as a rule, be sufficient to indicate which it is. The specific gravity of mineral or hydrocarbon oils will not exceed 0·920, while that of rosin oil will not be below 0·980.

*Adulteration of Linseed Oil with other Fatty Oils.*—This form of adulteration is exceedingly rare, inasmuch as linseed oil is usually the cheapest of fatty oils, and the price of such oils as rape, cotton or castor oils rarely falls below that of linseed oil; even then the difference of price is scarcely sufficient to induce the use of such oils for adulterating linseed oils. No simple tests can be given for detecting such adulteration. The analyst has to take into account the specific gravity of the sample, the proportion of caustic potash required to saponify the oil, the Maumene test, the iodine absorption, for a description of which tests the reader is referred to the author's books on *Lubricating Oils*, and on *Soaps*, issued by the publishers of the present work.

**Boiled Linseed Oil.**—It has been stated above that the property which gives linseed oil its value as a paint oil is that on exposure to the air it absorbs oxygen and becomes hard and resinous, or (as is commonly said) *dries*. This property of drying has been found to be increased by heating the oil, more especially if, during the process of heating, another body technically known as a *drier* be added, the presence of which appears to promote the absorption of oxygen by what is known to chemists (for want of more definite knowledge of the action) as *catalysis*. This action will be discussed presently. Oil thus heated is prepared on a large scale commercially and is known as *boiled oil*.

Boiled oil can be prepared by several processes; these are described in detail in the author's *Manual of Painter's Colours, Oils, etc.* It will be sufficient here to indicate in outline the chief methods:—

1. *The Fire Process.*—The oil is heated by fire in a suitable boiler to a temperature of 500° F. for some hours with more or less driers, the time of heating and the quantity of driers added being dependent on the quality of the boiled oil which it i

desired to make, as the finished product may vary from a pale oil (having drying properties but slightly better than those of raw oil) to a thick viscid oil (drying very quickly), while it is possible to produce a solid product by sufficient heating of the oil. This method is commonly employed, although it is becoming more and more superseded by other processes.

2. *The Steam Process.*—The oil with the driers is heated in a steam-jacketed boiler, steam at a high pressure being sent into the jacket. Air is blown into the oil during the operation. This process has the merit of yielding paler coloured oils than the fire process, and is freer from danger. It is now largely used.

3. *The Hartley-Blenkinsop Process.*—The oil is heated to a comparatively low temperature with a small quantity of manganese linoleate, air being blown in at the same time. The merit of this process lies in the fact that it yields an oil which is very pale in colour—paler even than the raw oil from which it is made—so that it may be used with pure white colours and pale bright tints without fear of discolouring them. At the same time the drying properties of the oil are perfectly satisfactory.

As prepared by either the fire or steam process, boiled oil is a dark, reddish coloured oil; the specific gravity varies considerably, samples of boiled oil having specific gravities ranging from 0·938 to 0·945 may be met with, while occasionally heavier samples are made. In its general properties boiled oil is similar to raw oil and the tests for it are the same. It, however, dries much more quickly, or in at least half the time, and with a more glossy surface. Boiled oil is scarcely ever used by itself in paint making, but is always mixed with raw oil; this is because, if used alone, it would leave a coat which is hard and liable to crack, owing to want of elasticity.

**Action of Driers on Oil.**—It has been well established that the drying of linseed oil is due to oxidation, the oil absorbing oxygen and forming the substance which has received the name of linoxyn. Now it has been found that by mixing the oil with certain metallic compounds the drying of the oil is much facilitated. The metallic salts which are found most effective are manganese dioxide, manganese sulphate, manganese acetate, litharge, red lead, lead acetate and a few others. The substances which have been found to be the most active as driers are compounds of metals, such as manganese, iron and lead, that form two or three compounds with oxygen, and their action as driers may be explained by their acting as carriers of oxygen from the air to the oil. During the operation of drying a certain amount of catalytic action occurs; the metallic compound takes up oxygen and forms a higher oxide, which gives up a portion of its oxygen to the oil, and re-forms the lower oxide; this absorbs more oxygen from the air and parts with the excess to the oil until the oil has become quite oxidised and *dry*. Usually the proportion of driers added is but small; from 1 to 2 per cent. of the oil is usually sufficient. Some of the metal of the driers enters into combination with the fatty acids of the oil and forms lead compounds or lead soaps, which are dissolved in the excess of oil present; and the probability is that these lead, or metallic, soaps have some influence on the lustre of the coat of oil which is left when the oil is spread over a surface.

Prof. W. N. Hartley, who has made many investigations on linseed oil, has, as the result of his experiments on this subject, come to the following conclusions:—

1. That the chemical action of the manganese compound, employed as a drier, is that of a carrier of oxygen from the atmosphere to the oil. Manganese oxide takes up oxygen from the air and transfers it to the oil, and in so doing it suffers alternately the opposite processes of oxidation and reduction.

2. That to obtain the best result the amount of manganese present must not exceed a certain small proportion of the oil.

3. Oil to which turpentine has been added dries more rapidly than oil without such addition, because the oil, being diluted and rendered thinner, is spread over a larger surface and is in contact with a much larger quantity of air or oxygen.

4. Turpentine does not act as a drier, that is, as a carrier of oxygen to the oil.

5. Different white pigments behave differently when drying; the more powerfully basic the properties of the pigment, the more powerful is its action as a drier. Lead oxide and white lead (basic carbonate of lead) combine more easily with the acids of linseed oil than does zinc oxide. But zinc oxide dries better than antimony oxide, because it is stronger in its basic properties; while arseniate of tin has no basic properties, therefore it is not a drier.

6. Indifferent substances, that is to say, those without chemical action on the oil (such as lamp black, barytes, lead sulphate), cannot act as driers. See Andés' *Vegetable Fats and Oils.*

**LITHARGE.**—This substance is the monoxide of lead, having the formula, PbO, and composed of 92·81 per cent. of lead and 7·19 per cent. of oxygen. It is obtained by melting lead in a suitable furnace and passing a current of air over the molten lead. The oxygen is absorbed; the resulting oxide is allowed to melt and is then run into suitable vessels. On cooling it breaks up into fragments, which again are easily broken up into flaky pieces and then form the flake litharge of commerce. Litharge is found in trade in two forms, *flake* and *powder*. The former is that in which it is first obtained. The latter is produced by grinding the former. Flake litharge has an orange brown colour and is somewhat lustrous. Powder litharge has a brownish buff colour. It is heavy, the specific gravity being 9·15, but varies slightly according to the mode of preparation.

It is readily soluble in dilute nitric acid and in acetic acid, forming colourless solutions of the nitrate and acetic of lead respectively. Boiling hydrochloric acid converts it into the chloride, which is soluble in the boiling liquor, but is deposited again on cooling in transparent crystals. Sulphuric acid converts litharge into white, insoluble sulphate of lead. Litharge is also soluble in solutions of the caustic alkalies, forming colourless solutions. It is also soluble in solutions of the normal acetate of lead, yielding solutions of basic acetate.

Litharge is used for a great variety of purposes : in making glass, cements, colours, pottery, and lead salts, as also for calico printing, dyeing, etc.

Commercial litharge is usually very nearly pure, very little adulteration being carried on. It ought to be completely dissolved by acetic acid, and to form a colourless solution ; not more than a mere trace of insoluble matter should be left behind, and that ought to be brownish oxide of lead.

**LITHOPHONE,** the name given to a white pigment, consisting of a mixture of zinc sulphide, zinc oxide and barium sulphate, made by the same process as is used for Orr's White. See *Orr's White.*

**LOKAO,** the Chinese name of Chinese Green. See *Chinese Green.*

## M.

**MADDER** is the ground root of the madder plant, *Rubia tinctoria.* At one time this plant was largely cultivated in various countries of Southern Europe, the root being used in the dyeing of textile fabrics in the favourite Turkey red, a colour renowned for its fastness to washing, light, etc. Now, however, it is only grown to a slight extent, the advance of chemistry having shown how the principle, alizarin, to which the madder owes its colouring power, can be more cheaply produced artificially. From madder was made madder lakes—pigments which are largely used by artists.

Madder contains two colouring principles (not present in the fresh madder, as such, but in the form of glucosides), which, by the action of ferments or alkalies or acids, decompose and yield alizarin and purpurin, together with a glucose sugar. The amount present in the madder root is small; at the most not exceeding 3 per cent. For the purposes of dyeing, etc., it is not necessary to extract the colouring principles from the madder, as the latter may be used directly. Considering that madder has become almost obsolete it is not necessary to describe it in detail. Those readers who desire further information will find it in Knecht and Rawson's *Manual of Dyeing*.

**MADDER LAKE.**—The colouring principles of madder, alizarin and purpurin, have the property of forming with alumina, lime, iron and other metallic oxides, insoluble colour lakes. It is upon this property that their application in dyeing and textile printing depends. It is also upon the same property that the use of madder in the manufacture of lake pigments is based. Madder lakes have been, and are now, largely used by artists, chiefly on account of their brightness of tint and their fastness to light and air, in which respects they excel all other lakes.

**MAGNESIA** is the oxide of the metal magnesium, and has the chemical formula, $MgO$. It is composed of 60 per cent. magnesium and 40 per cent. oxygen. It is usually prepared by heating the carbonate or the hydrate, when it is left behind as a bulky white powder which constitutes the calcined magnesia of the shops. Its specific gravity is 3·07. When very strongly heated it may rise to 3·6. It is infusible under ordinary conditions, and can only be melted by employing the oxyhydrogen blowpipe. It is almost insoluble in water, 1 part of magnesia dissolving in 55,000 parts of water. Magnesia is faintly alkaline. It dissolves in all acids, forming the magnesium salts, of which the most important are the chloride and the sulphate.

Magnesia is used in medicine, in the preparation of cements, and for making infusible bricks, pottery, etc.

Magnesia should be completely soluble in acetic, hydrochloric or sulphuric acids. The solution should not give any precipitates on successive addition of ammonium chloride, ammonia, ammonium sulphide and ammonium carbonate. Ammonium or sodium phosphate throw down white crystalline precipitates of ammonium magnesium phosphate from ammoniacal solutions of magnesia.

The amount of magnesia can be determined by taking a known weight of the sample, dissolving it in water or acid, then adding ammonium chloride and ammonia in slight excess. A solution of ammonium or sodium phosphate is then added and the mixture put in a warm place for a few hours to ensure the complete precipitation of the magnesia; the precipitate is next filtered off, washed well with water containing a little ammonia, dried and then burnt in a weighed crucible, the residue being magnesium pyrophosphate. The weight of this multiplied by 0·36036 gives the amount of magnesia, $MgO$, present.

**MAGNESITE,** the natural carbonate of magnesium. It is found in large, hard and compact masses, of a white colour. Occasionally it is met with in the form of rhomboidal crystals. In combination with an equivalent proportion of calcium carbonate it forms the rock known as dolomite. In an hydrated form it is obtained by adding a solution of an alkaline carbonate to one of a magnesium salt. Magnesite contains 28·57 per cent. of magnesium, 14·29 per cent. of carbon, and 57·14 per cent. of oxygen, and has the formula, $MgCO_3$. It is insoluble in water, but soluble in water containing carbonic acid in solution, from which, on evaporation, an hydrated carbonate can be obtained in a crystalline form.

The natural carbonate is used in commerce as the source for preparing some magnesium salts, and, when ground fine, as a white pigment. Precipitated magnesium carbonate is known as *magnesia alba*, and two varieties, *light* and *heavy*, are distinguished. The former is prepared by precipitating cold solutions and the latter by precipitating hot solutions of magnesium sulphate or chloride. Magnesium carbonate in any of its forms is soluble in acetic, hydrochloric or sulphuric acids with effervescence, the corresponding magnesium salts being formed.

The tests for magnesite are similar to those for magnesia.

**MAGNESIUM.**—This metal is found widely distributed in nature. It is present in many waters in the form of carbonate and sulphate. Many mineral waters owe their therapeutical value to the presence of the sulphate in notable quantity. In sea water it is present as chloride, and much of the peculiar saline taste of sea water is due to its presence. As magnesium compounds, carbonate, sulphate, etc., it is found in many minerals and rock masses, but the metal itself is never found native. Magnesium is a silver-white metal, which becomes slightly oxidised on exposure to air. It is soft, readily cut, ductile and malleable. When heated it burns with a most brilliant light, rich in actinic rays; hence is largely used by photographers for taking photographs by artificial light. When burning it forms the oxide as a fine white and bulky powder. Magnesium is soluble in nearly all acids, with evolution of hydrogen and the formation of the corresponding salt. When boiled with alkalies it is dissolved, hydrogen being evolved. Magnesium has an atomic weight of 24 and the symbol Mg. It is a dyad metal, forming with acids, salts of the type of the chloride, $MgCl_2$, the sulphate, $MgSO_4$, and the carbonate, $MgCO_3$. Most of the magnesium compounds are soluble in water, the oxide, carbonate and phosphate being the chief insoluble compounds. The oxide and carbonate have already been described. The tests also have been noted under magnesia. See *Magnesia*.

**MALACHITE.**—A natural basic carbonate of copper usually containing 19·9 per cent. of carbonic acid, $CO_2$, 71·9 per cent. of oxide of copper, CuO, and 8·2 per cent. of water, $H_2O$. The formula is $CuCO_3$, $CuH_2O_2$. It is found in large masses in Siberia and in other localities. It is used as an ornamental stone and for pigment purposes, being then sold under the name of mountain green or mineral green. It is also used as an ore of copper. It has a specific gravity varying from 3·5 to 4, and is easily powdered. Its usual colour is a bright, medium shade of green of a yellowish tone, but it can be found in a great variety of tints. When heated it is decomposed, a black residue of oxide of copper being left, while the carbonic acid and water are driven off. Acids dissolve it with effervescence, owing to the evolution of carbonic acid, the corresponding copper salts being formed. As a pigment it is quite permanent when exposed to air under ordinary conditions.

It is, however, blackened by sulphuretted hydrogen and sulphurous vapours. It has a fair amount of body and covering power. Its use as a pigment is, however, becoming obsolete, the Brunswick greens which take its place being much superior.

Mountain green may be detected by turning black on being heated strongly in a small crucible, by dissolving with effervescence in acids, by its solutions having a green colour, and by these solutions giving the following reactions with chemical reagents: Ammonia forms a deep blue solution (which is eminently characteristic of copper). Sulphuretted hydrogen throws down a black precipitate of copper sulphide. Caustic soda throws down a bluish-white precipitate of copper hydroxide, which, on the mixture being boiled, changes into the black oxide of copper. Potassium ferrocyanide throws down a brown precipitate of copper ferrocyanide.

**MANGANESE,** the name given to the natural oxide of the metal manganese. See *Manganese Dioxide*.

**MANGANESE ACETATE.**—This salt of manganese (prepared by dissolving precipitated oxide of manganese in acetic acid) has a composition corresponding to the formula, $Mn2C_2H_3O_2$. It is occasionally used as a drier. Its action as a drier is very powerful owing to the fact that it readily parts with its acid, thus enabling the oxide of manganese to unite with the oil and to act as a carrier of oxygen. It has the advantage over the oxide of manganese in that it yields a paler oil.

**MANGANESE BLACK.**—Under this name the natural oxide of manganese has been sold as a pigment. For this purpose its use is disadvantageous. First, owing to its expense;

second, owing to the brownish hue of its colour; and, lastly, owing to its powerful drying properties, which, when used as a pigment, causes the oil to become over oxidised and to yield a coat which is hard and brittle, and, therefore, not durable.

**MANGANESE BORATE.**—This substance, which is largely used as a drier, is made by precipitating solutions of manganese salts with solutions of borax. If the precipitate is dried it has, according to Prof. Hartley (*Chemical Society's Journal*, vol. xliii., p. 129), a composition indicated by the formula, $MnH_4(BO_3)_2H_2O$. Heated to 100° C. (212° F.) it loses its water of hydration and then has the formula, $NnH_4(BO_3)_2$; while at higher temperatures it loses more water, until, at a bright red heat, it has the composition, $Mn(BO_3)_2$. In making borate of manganese it is better to add a little caustic soda to the solution of borax used. As found in commerce it is a powder of a faint pinkish hue, insoluble in water, but somewhat soluble in alkaline solutions. As a drier it is superior to the lead driers, but inferior to manganese itself; but it possesses the advantage that it does not darken the oil as much as either manganese or even any lead compounds do.

**MANGANESE BROWN.**—Some of the natural brown oxides of manganese, as also the precipitated variety, have been sold as pigments under this name, but their use is far from satisfactory, for the same reasons as militate against the use of the black oxide of manganese as a pigment. See *Manganese Black*.

**MANGANESE COMPOUNDS** give the following reactions: Ammonia throws down a pale brown precipitate, which darkens on exposure to the air. This precipitate does not form in the presence of a large excess of ammonium chloride; hence in any circumstance the precipitation is not complete. Sodium hydrate throws down a pale brown precipitate of manganous hydrate, which turns dark brown on exposure to the air. This darkening of the colour is eminently characteristic of manganese. Ammonium sulphide added to ammoniacal solutions of manganese throws down a drab-coloured precipitate of manganese sulphide, MnS, which is insoluble in acetic acid, but soluble in hydrochloric acid. Manganese, when present, can be estimated as the tetroxide, $Mn_3O_4$, by taking a weighed portion of the manganese compound, dissolving in water or acid (as the case may require), and adding a solution of sodium carbonate. This precipitates the manganese as carbonate. The mixture is allowed to stand for an hour to complete the precipitation of the manganese, and filtered; the precipitate on the filter is well washed, dried and ignited in a crucible, when it decomposes into the tetroxide, $Mn_3O_4$, which is then weighed. Or, instead of precipitating as carbonate, the manganese may be precipitated as sulphide by the use of ammonium sulphide. This precipitate is filtered off, washed, dried and ignited in a porcelain crucible and the weight of the residual oxide, $Mn_2O_3$, ascertained.

**MANGANESE DIOXIDE, BLACK OXIDE OF MANGANESE.**—This substance occurs naturally in large quantities, and is known to mineralogists as pyrolusite. It is a heavy black powder, which, when heated strongly, gives off oxygen. It is a peroxide, having the composition indicated by the formula, $MnO_2$. When heated with acids it gives rise to oxidation products and to the formation of the manganese salts corresponding to the next lower basic oxide of manganese, MnO. Thus with sulphuric acid it yields oxygen and manganese sulphate; with hydrochloric acid, chlorine and manganous chloride. The natural product is not entirely soluble, a little silica, etc., being left as an insoluble residue. Manganese dioxide is also prepared artificially in large quantities by Weldon's process for the recovery of manganese used in the manufacture of bleaching powder, this artificial product being usually known as *Weldon Mud*, and sold in the form of a paste. Manganese dioxide is used as a drier in making boiled oil and varnishes. It is the best drier known, but has the disadvantage of discolouring the oil somewhat. By using the browner grades of the natural oxides of manganese this difficulty may be overcome to a great extent. Usually from ½ to 1 per cent. will be found sufficient to produce a strongly drying oil. It is also used in glass and pottery manufacture to produce reddish shades and as an oxidising agent.

**MANGANESE GREEN.**—A green pigment can be made by heating together oxide of manganese, nitrate and sulphate of barium, but it has never come into practical use.

**MANGANESE LINOLEATE.**—This manganese soap is prepared by saponifying linseed oil by means of caustic potash and pouring the resulting soap solution into one of manganese sulphate, the manganese soap separating out in the form of curdy masses. These are separated, washed with warm water and dried. It is employed in the Hartley-Blenkinsop process of boiling oil, in which it acts not only as a drier but also as a bleaching agent on the chlorophyll naturally present in the oil.

**MANGANESE OXALATE,** $MnC_2O_4$, is prepared by dissolving freshly precipitated oxide of manganese in oxalic acid and evaporating the solution to dryness. Of late it has been proposed to be used as a drier in oils and paints, its peculiar advantages for which are said to be that it readily undergoes decomposition into oxide of manganese (which combines with the oil), and carbonic acid and water (which pass away).

**MANGANESE SULPHATE,** $MnSO_4$, is prepared by dissolving manganese oxide in sulphuric acid and evaporating the solution to dryness. It is largely used as a drier in making paints and varnishes. It is a salt of a faint pinkish colour, and is stable when exposed to the air. Some samples of commercial manganese sulphate are deliquescent, owing to their containing a small quantity of the deliquescent chloride. Manganese sulphate is readily soluble in water. It does not decompose when heated. Its special advantages as a drier are that it does not tend to discolour the oil as does the black oxide of manganese, while it is nearly as powerful as the latter substance.

**MANILA COPAL.**—This resin is imported from Manila in the Philippine Islands. It is the product of various species of trees which grow in many islands of this group. From these trees it is collected by the natives who send it to Manila for export to Europe and America. In appearance Manila copal is rather variable, but generally it comes in the form of pebble-like pieces of a pale brownish colour, varying somewhat both in size and tint. It is rather soft, but tends to become hard with age. Its specific gravity is about 1·062. It melts at from 230° to 250° F., and at a temperature slightly above begins to distil, the distillate consisting of an aqueous portion of an acid character and an oily portion with a strong empyreumatic odour. Manila copal is soluble to a large extent in methylated spirit and alcohol, partially soluble in amyl alcohol (fusel oil), and completely soluble in a mixture of methylated spirit and amyl alcohol. It is soluble in ether, but only partially so in benzene, turpentine, chloroform and petroleum spirit, the insoluble portion usually forming a white gelatinous mass. There are some differences between different samples of Manila copal in regard to their solubility in solvents, some being more so than others. Roughly, two varieties are recognised in trade, *hard* and *soft*, the former being less soluble than the latter. Manila copal which has been melted by heat does not become any more soluble in alcohol, but is more freely soluble in other solvents.

Manila copal is largely used in making spirit varnishes and enamel paints. It is rather more elastic than shellac; hence, when used in conjunction with the latter resin, it imparts elasticity to the coat of varnish left behind on evaporation of the solvent. Manila copal makes fairly durable varnishes

**MASTIC.**—See *Gum Mastic.*

**MENHADEN OIL.**—This oil is derived from the Menhaden fish, *Alosa Menhaden*, found in great abundance off the east coast of North America. It is a brownish-coloured oil, the crude qualities being rather turbid, and the refined grades fairly clear. It has a characteristic fishy odour and taste. Its specific gravity ranges from 0·927 to 0·932 at 60° F. It solidifies at $-4°$ C. It requires 19·2 per cent. of caustic potash to saponify it, absorbs 147·9 per cent. of iodine, and, when mixed with sulphuric acid (Maumene test), the temperature rises to 126° C. It usually contains a small but variable quantity (0·8 to 1·5 per cent.) of unsaponifiable matter. It is employed for a variety of purposes, particularly in leather making and in painting. When exposed to the air it dries well, giving a hard coat.

**METHYL ALCOHOL.**—When wood is distilled there is obtained a light spirituous liquid known as wood spirit. This has rather a complex composition, containing methyl alcohol, $CH_3OH$ (to the extent of from 50 to 80 or even 90 per cent.); acetone, $(CH_3)_2CO$; allyl alcohol, $C_3H_5OH$; furfurol, etc. This wood spirit has a characteristic, but rather unpleasant, odour and a nauseous taste. By repeated distillation over lime or soda most of the impurities may be removed. Refined wood spirit is employed in the preparation of methylated alcohol and in varnish making, as it is a good solvent for resins, in this property rivalling alcohol, which, perhaps, is due to the presence of the acetone and other alcoholic bodies.

Methyl alcohol itself may be prepared from wood spirit by a complicated process of purification. It is a colourless liquid, very mobile and volatile, with a spirituous and fragrant odour. Its boiling point is 55° C. The specific gravity at 15·5 C. is 0·8021, but authorities differ owing to the great difficulty of obtaining it in a pure condition. It mixes in all proportions with water, ethyl alcohol, ether, turpentine, etc., and has great solvent powers for resins, gums, etc. It has the chemical formula, $CH_3OH$. When subjected to the action of oxidising agents it is changed first into formaldehyde, $HCOH$, and subsequently into formic acid, $HCOOH$.

The following reactions serve to distinguish methyl alcohol from wood spirit: With the latter caustic soda produces a brown colour, sulphuric acid a red colour, the depth of which is increased on heating the mixture. On adding a solution of mercurous nitrate a grey precipitate of mercury is obtained. It is not easy to distinguish methyl from ethyl alcohol, both bodies having very similar properties. One test is based on the fact that when methyl alcohol is subjected to the action of oxidising agents it is oxidised to formaldehyde, a body having strong reducing properties; while ethyl alcohol yields under similar circumstances acetic aldehyde, which has no reducing properties. Three to four c.c. of the spirit to be tested are mixed in a flask with 25 c.c. of water, 2½ c.c. of sulphuric acid, and 3 grammes of potassium bichromate. The mixture is allowed to stand for a quarter of an hour and then distilled. When 25 c.c. have come over the distillate (which will be acid in character) is neutralised by the addition of sodium carbonate. It is then boiled down a little and a trace of acetic acid followed by a little silver nitrate added. A mere darkening of the colour may be neglected, but a copious precipitate of a brown or black colour shows the presence of methyl alcohol.

Another method of detecting the presence of methyl alcohol or wood spirit depends upon the fact that commercial methyl alcohol and wood spirit contain acetone and other bodies which have a reducing action on potassium permanganate. One hundred c.c. of the spirit to be tested is distilled and the distillate collected in 10 c.c. fractions. To each fraction a little potassium permanganate is added. If methyl alcohol or wood spirit be present the permanganate will be reduced in every fraction, but if only ordinary alcohol be present the first two fractions only will reduce the permanganate, this reduction being due to the presence of aldehyde in small quantities, which concentrate in the first portions of the distillate. See also *Alcohol*.

**METHYLATED SPIRIT.**—This important varnish solvent is a mixture of 90 per cent. of ordinary alcohol (spirit of wine) with 10 per cent. of wood spirit. This mixture is permitted to be used under special regulations by the excise authorities for manufacturing purposes free of duty, the addition of the wood spirit rendering the use of the spirit for drinking purposes unusable. With a view to still further preventing its use for drinking, and having regard to the fact that of late many improvements have been made in the extraction of wood spirit from the crude wood naphtha, the authorities have made the addition of a little petroleum oil to the methylated spirit sold in retail compulsory. Where, however, it is necessary to use a methylated spirit free from this addition they will give special permission for its use.

Methylated spirit is usually sold at a strength of "64 over proof," having a specific gravity of 0·821, and containing about 90 per cent. of real alcohol. The meaning of the term "64 over proof" is that when 100 volumes of such spirit are mixed with 64 volumes of water it yields "proof spirit," which is a liquid which will not cause gunpowder to fire when a little is poured over it and a light applied. This term *proof* is very vague and should be given up. It would be better to sell the spirit according to the amount of the real alcohol it contains.

The strength of methylated spirit may be ascertained with sufficient accuracy by ascertaining its specific gravity and then referring to the table given under *Alcohol*.

Methylated spirit generally has an acid reaction due to its containing small quantities of acetic acid and aldehyde. Besides these it contains traces of other alcoholic bodies, amyl alcohol, propyl alcohol, water, acetone, etc.

The quality of methylated spirit may be roughly ascertained by distilling 100 c.c. of the spirit. All or nearly all should be distilled over below 100° C., the great bulk passing over between 80° and 90° C. If much is left in the retort after the temperature reaches 90° C. it is an indication of the presence of excess of water.

Methylated spirit is largely used in making shellac varnishes and polishes; rosin, dammar, sandarac and other resinous varnishes; and enamel paints. For all these purposes it is necessary to have a spirit of 90 to 92 per cent.

strength. Weaker spirit has little solvent action on the resins. Varnishes made with methylated spirit dry quickly, usually in from ten to fifteen minutes. The character of the coat they leave behind depends entirely upon the character of the resins, etc., used in making them.

What is known as *Finish* is methylated spirit containing about 3 oz. per gallon of rosin. On the sale of this article the excise authorities place no restriction. It may be distinguished from methylated spirit by its forming a copious white precipitate on being poured into water.

The article on *Alcohol* and *Methyl Alcohol* should be consulted for the chemical properties of methylated spirit.

**MICA.**—Common mica is a double silicate of potash and alumina, but there are micas in which the potash is replaced by soda, lime or magnesia. The characteristic feature of the micas distinguishing them from other double silicates (the felspars for example) is that they occur in thin plates and have the property of cleavage very highly developed, so much so that they can be readily split up into very thin slices. They are very transparent minerals and have a great power of resisting heat; hence mica is much used for making chimneys for oil lamps and in other ways where a transparent substance capable of resisting heat is required. Mica forms one of the constituents of a typical granite, in which it is present in the form of small flakes. It is not, however, present in all granites. In some it is replaced by hornblende or augite. The common mica is known to mineralogists as muscovite. Its composition varies somewhat, and ranges from 43 to 52 per cent. of silica, $SiO_2$; 33 to 42 per cent. of potash, $K_2O$; 10 to 12 per cent. of alumina, $Al_2O_3$; and 0 to 6 per cent. of water, $H_2O$. Sometimes small quantities of oxide of iron, lime and magnesia are also present; while fluorine is an almost constant constituent.

It possesses great elasticity and is one of the most transparent of the micas. It is the form usually present in granite. It occurs in crude china clay, and the levigating process to which that substance is subjected has as one of its objects the separation of the mica (see *China Clay*). Another very common mica is biotite, the magnesia mica, the range in the composition of which is 36 to 45 per cent. of silica, 16 to 40 per cent. of magnesia (MgO), 30 to 36 per cent. of alumina, and 0 to 4·5 per cent. of water. It is usually of a dark colour, in some cases almost black. Its elasticity is slight and its transparency small. It is present in small quantities in some granites, but it is chiefly found in volcanic rocks, and altered igneous rocks. The other micas are of no moment.

Besides the uses given above, mica has been used in the preparation of lubricating greases, for which purposes, however, it is not to be recommended.

**MINERAL GREEN.**—The name often given to malachite (see *Malachite*). Artificial mineral greens imitative of the natural malachite have often been prepared from sulphate of copper, arsenic, etc., but have not been successful, owing to their lacking the depth of colour and brilliance of tone of the original. In their properties such greens resemble verditer.

**MINERAL WHITE.**—The name given to ground gypsum. See *Gypsum.*

**MONTPELIER YELLOW.**—Another name for Turner's yellow. See *Turner's Yellow.*

**MOUNTAIN GREEN.**—Under this name malachite is used as a pigment. See *Malachite.*

**MOUNTAIN BLUE.**—The name given to azurite, which is a natural basic carbonate of copper resembling malachite in its composition and properties, but having a bright blue colour.

## N.

**NAPLES YELLOW.**—This old and well-known pigment is a compound of the oxides of lead and antimony prepared by several processes. At one time it was largely used as a pigment on account of the brightness of its colour and its good properties as a pigment; but of late years it has been replaced by the chrome yellows, which are at once brighter, have more colouring power and are cheaper.

**NAPHTHA.**—A common name for light liquids, employed in the various chemical and allied industries as solvents for various bodies, resins, gums, india-rubber, etc. The varieties of naphtha are named according to their source. Thus, there is wood naphtha, obtained in the distillation of wood (see *Methylated Spirit*); coal-tar naphtha (see *Coal-tar Naphtha*), obtained in the distillation of coal for coal gas; shale naphtha, obtained in the distillation of Scotch shale for the manufacture of burning and lubricating oils (see *Shale Naphtha*); and petroleum naphtha or benzoline (see *Benzoline* and *Petroleum Naphtha*).

**NICKEL OXIDE,** NiO, is a pale, greyish-green powder, quite stable when exposed to the air, insoluble in water but soluble in acids, with the formation of the corresponding nickel salts. It is prepared by heating the carbonate or nitrate of nickel rather strongly. Nickel oxide is also found naturally as the mineral bunsenite, but only in small quantities. Nickel oxide is used to some extent in the manufacture of pottery for producing a brown colour. The nickel oxide usually sold is a very pure article. It should be almost entirely soluble in acids, the solution giving the following reactions: No precipitates with either hydrochloric acid or sulphuretted hydrogen in the acid solution. Ammonia should give a greenish precipitate, easily soluble in excess of the reagent. If ammonium sulphide be added to the ammoniacal solution a black precipitate of nickel sulphide is obtained. A little of the nickel oxide, when fused with borax before the blowpipe, should give a sherry-coloured bead. Caustic soda gives an apple-green precipitate of nickel hydroxide, which is soluble in acids or ammonia. Potassium cyanide throws down a green precipitate of the cyanide, which is soluble in excess of the reagent. The solution of potassium cyanide used should be freshly made.

**NIGER SEED OIL.**—This oil is obtained from the seeds of the niger plant, *Guizotia oleifera*, which grows largely in the Niger districts of West Africa. It is a pale yellow rather limpid oil, with a peculiar taste and smell. When exposed to the air it becomes rather viscid, but does not dry well. Its specific gravity ranges from 0·924 to 0·928. It requires from 18·9 to 19·2 per cent. of caustic potash to saponify it. It absorbs 132 per cent. of iodine, and with sulphuric acid gives a rise in temperature of 82° C. It is used to a small extent only. It is not a good lubricant, being rather apt to gum, while it does not dry sufficiently well to be used as a paint oil. Its most suitable use is as a food oil.

**NITRE.**—The common name for potassium nitrate. See *Potassium Nitrate.*

**NITRIC ACID.**—This important acid is a compound of the three elements, hydrogen, oxygen and nitrogen, in the proportion of 1 part by weight of hydrogen, 48 parts of oxygen and 14 parts of nitrogen, and has the chemical formula $HNO_3$. It is obtained by heating either potassium nitrate or sodium nitrate with sulphuric acid in retorts; the nitric acid passes over in vapour and is collected in condensers. This acid is of a yellowish colour due to its containing oxides of nitrogen. These can be removed by redistilling and passing a current of air through.

Pure nitric acid is a colourless, limpid, fuming and powerfully corrosive liquid. It begins to boil at 187° F. (86° C.), but the boiling point rises to 250° F. (121° C.), at which it remains steady. The ordinary acid has a specific gravity of 1·424 (85° Tw.), and contains about 70·5 per cent. of actual nitric acid.

The most common impurities in nitric acid are chlorine, sulphuric acid, nitrous acid, iron, saline salts.

Nitric acid acts upon metals very strongly, but its action is governed by the metal in question and the strength and temperature of the acid. This arises from the fact that nitric acid is an unstable acid and readily decomposes with the evolution of oxides of nitrogen which have a reddish colour. Strong nitric acid attacks copper, silver, zinc, lead, iron, forming the nitrates of the metals with evolution of nitric oxide. Sometimes nitrogen is given off. Tin, antimony and a few other metals are oxidised to the oxide, tin for example being converted to the white metastannic acid, antimony to antimony oxide. Magnesium, zinc, lead, and a few other metals are acted upon by dilute nitric acid forming the nitrate, ammonia often being formed at the same time. The nitrates of the metals are much used for various purposes. They are all soluble in water.

The following table gives the specific gravities and strengths of nitric acids:—

### SPECIFIC GRAVITY OF NITRIC ACID AT 60° F.

| Specific Gravity. | Twaddell. | Per Cent. of $HNO_3$ by Weight. | Pounds of $HNO_3$ per Gallon. | Specific Gravity. | Twaddell. | Per Cent. of $HNO_3$ by Weight. | Pounds of $HNO_3$ per Gallon. |
|---|---|---|---|---|---|---|---|
| 1·100 | 20 | 16·80 | 1·848 | 1·320 | 64 | 50·63 | 6·683 |
| 1·105 | 21 | 17·57 | 1·941 | 1·325 | 65 | 51·40 | 6·810 |
| 1·110 | 22 | 18·35 | 2·037 | 1·330 | 66 | 52·24 | 6·948 |
| 1·115 | 23 | 19·12 | 2·132 | 1·335 | 67 | 53·09 | 7·087 |
| 1·120 | 24 | 19·89 | 2·227 | 1·340 | 68 | 53·94 | 7·228 |
| 1·125 | 25 | 20·67 | 2·235 | 1·345 | 69 | 54·79 | 7·369 |
| 1·130 | 26 | 21·44 | 2·423 | 1·350 | 70 | 55·64 | 7·511 |
| 1·135 | 27 | 22·21 | 2·520 | 1·355 | 71 | 56·53 | 7·660 |
| 1·140 | 28 | 22·98 | 2·620 | 1·360 | 72 | 57·42 | 7·809 |
| 1·145 | 29 | 23·76 | 2·720 | 1·365 | 73 | 58·31 | 7·959 |
| 1·150 | 30 | 24·53 | 2·821 | 1·370 | 74 | 59·21 | 8·112 |
| 1·155 | 31 | 25·30 | 2·922 | 1·375 | 75 | 60·10 | 8·264 |
| 1·160 | 32 | 26·08 | 3·025 | 1·380 | 76 | 61·00 | 8·418 |
| 1·165 | 33 | 26·85 | 3·128 | 1·385 | 77 | 61·97 | 8·583 |
| 1·170 | 34 | 27·62 | 3·231 | 1·390 | 78 | 62·95 | 8·750 |
| 1·175 | 35 | 28·40 | 3·337 | 1·395 | 79 | 63·92 | 8·917 |
| 1·180 | 36 | 29·17 | 3·442 | 1·400 | 80 | 64·90 | 9·086 |
| 1·185 | 37 | 29·94 | 3·548 | 1·405 | 81 | 66·01 | 9·274 |
| 1·190 | 38 | 30·71 | 3·654 | 1·410 | 82 | 67·12 | 9·464 |
| 1·195 | 39 | 31·49 | 3·763 | 1·415 | 83 | 68·23 | 9·653 |
| 1·200 | 40 | 32·26 | 3·871 | 1·420 | 84 | 69·34 | 9·846 |
| 1·205 | 41 | 33·02 | 3·919 | 1·425 | 85 | 70·45 | 10·04 |
| 1·210 | 42 | 33·79 | 4·088 | 1·430 | 86 | 71·83 | 10·27 |
| 1·215 | 43 | 34·55 | 4·198 | 1·435 | 87 | 73·21 | 10·50 |
| 1·220 | 44 | 35·32 | 4·309 | 1·440 | 88 | 74·59 | 10·76 |
| 1·225 | 45 | 36·08 | 4·442 | 1·445 | 89 | 75·98 | 10·97 |
| 1·230 | 46 | 36·85 | 4·532 | 1·450 | 90 | 77·36 | 11·22 |
| 1·235 | 47 | 37·61 | 4·645 | 1·455 | 91 | 78·75 | 11·46 |
| 1·240 | 48 | 38·38 | 4·759 | 1·460 | 92 | 80·13 | 11·70 |
| 1·245 | 49 | 39·15 | 4·874 | 1·465 | 93 | 81·52 | 11·95 |
| 1·250 | 50 | 39·91 | 4·988 | 1·470 | 94 | 82·90 | 12·19 |
| 1·255 | 51 | 40·68 | 5·105 | 1·475 | 95 | 84·28 | 12·43 |
| 1·260 | 52 | 41·44 | 5·221 | 1·480 | 96 | 85·66 | 12·68 |
| 1·265 | 53 | 42·21 | 5·328 | 1·485 | 97 | 87·05 | 12·93 |
| 1·270 | 54 | 42·97 | 5·457 | 1·490 | 98 | 88·43 | 13·18 |
| 1·275 | 55 | 43·74 | 5·577 | 1·495 | 99 | 89·82 | 13·43 |
| 1·280 | 56 | 44·50 | 5·696 | 1·500 | 100 | 91·20 | 13·68 |
| 1·285 | 57 | 45·27 | 5·817 | 1·505 | 101 | 92·66 | 13·94 |
| 1·290 | 58 | 46·04 | 5·939 | 1·510 | 102 | 94·13 | 14·21 |
| 1·295 | 59 | 46·80 | 6·060 | 1·515 | 103 | 95·59 | 14·48 |
| 1·300 | 60 | 47·57 | 6·184 | 1·520 | 104 | 97·06 | 14·75 |
| 1·305 | 61 | 48·33 | 6·307 | 1·525 | 105 | 98·53 | 15·02 |
| 1·310 | 62 | 49·10 | 6·432 | 1·530 | 106 | 100·00 | 15·30 |
| 1·315 | 63 | 49·86 | 6·556 | | | | |

Nitric acid may be examined for strength by weighing out 5 grammes, diluting to 250 c.c., taking 25 c.c. out and titrating with normal standard solution of caustic soda, using phenol-phthalein or litmus as indicator, the number of c.c. of alkali used is multiplied by 0·063 to find the weight of $HNO_3$ present.

The presence of sulphuric acid or sulphates is ascertained by diluting the acid with water and adding barium chloride, when a white precipitate of barium sulphate is obtained if any be present. The presence of chlorine is ascertained by adding to a little of the diluted acid some silver nitrate, which will give a white precipitate of silver chloride if any be present. If iron is present a brown precipitate is obtained on adding ammonia.

Nitric acid is also known as aqua fortis; a mixture with hydrochloric acid, as aqua regia, this is the only acid liquid which will dissolve gold.

The cruder grades of nitric acid containing much nitrogen oxides in solution are often called nitrous acid in commerce.

**NON-POISONOUS WHITE LEAD.**—Under this term there are offered to painters mixtures of sulphate of lead, zinc white, barytes, etc., prepared by various processes. Generally they are very good pigments, having good body and covering power and are very durable. These pigments should be examined for their body, covering power, etc., as they vary considerably in these properties. It is difficult to give chemical reactions for these non-poisonous white leads, owing to the differences in their chemical composition. The presence of barium sulphate is ascertained by there being an insoluble residue on treatment with strong hydrochloric acid. The presence of zinc oxide can be ascertained by treating the white with dilute nitric acid, filtering off the insoluble portion and adding to the solution ammonia and ammonium sulphide, when a white precipitate of zinc sulphide will be obtained if zinc white be present. The presence of lead sulphate may be ascertained by treating the residue from the nitric acid with hydrochloric acid, dividing the solution into two portions. To one barium chloride is added when a white precipitate of barium sulphate insoluble on boiling will be obtained. The other portion is allowed to cool when crystals of lead chloride will separate.

## O.

**OCHRES.**—A most important group of natural pigments of a yellow colour found naturally in many places. In this country it is found in Oxfordshire (the ochre from which is esteemed the best), Devonshire, Derbyshire, Cornwall, Cumberland, Wales, Ireland, etc. It is found largely in France, especially in the district round Paris, the French ochres having a good reputation; in America, South Australia and in other places. The colour of ochres varies considerably from a bright yellow, in the case of the Oxford, French and Welsh ochres, to a reddish-yellow in the case of the Cumberland and Derbyshire ochres. Ochres, however, from the same localities are liable to vary. The depth of colour is also variable. In some it is very strong, in others very weak.

Ochres owe their colour to the presence of oxide of iron in a hydrated condition (see *Limonite*), which, in these pigments, is mixed with silica, silicate of alumina, lime, barytes and other earthy matters, these varying according to the character of the rock masses in which the ochre is found. The following analyses of the chief varieties of commercial ochres will show the nature of their composition:—

1. *Oxford Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic . . . . . | 6·88 |
| Water, combined . . . . . | 8·15 |
| Calcium oxide, $CaO$ . . . . . | 0·99 |
| Sulphur trioxide, $SO_3$ . . . . | 1·32 |
| Alumina, $Al_2O_3$ . . . . . | 6·47 |
| Ferric oxide, $Fe_2O_3$ . . . . . | 12·82 |
| Silica, $SiO_2$ . . . . . . | 63·47 |

2. *Welsh Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic . . . . . | 2·00 |
| Water, combined . . . . . | 12·50 |
| Sulphur trioxide, $SO_3$ . . . . | 1·31 |
| Silica, $SiO_2$ . . . . . . | 29·72 |
| Alumina, $Al_2O_3$ . . . . . . | 33·31 |
| Ferric oxide, $Fe_2O_3$ . . . . . | 20·70 |
| Copper sulphide, $CuS$ . . . . | 0·51 |

3. *Irish Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic . . . . . | 9·05 |
| Water, combined . . . . . | 12·00 |
| Insoluble matter . . . . . | 32·50 |
| Sulphur trioxide, $SO_3$ . . . . | 2·68 |
| Alumina, $Al_2O_3$ . . . . . | 16·77 |
| Ferric oxide, $Fe_2O_3$ . . . . . | 26·38 |
| Calcium oxide, $CaO$ . . . . . | 0·25 |
| Copper oxide, $CuO$ . . . . . | 0·63 |

4. *Derbyshire Ochre :—*

| | Per Cent. |
|---|---|
| Water, combined . . . . . | 6·10 |
| Barium sulphate, $BaSO_4$ . . . . | 20·96 |
| Silica, $SiO_2$ . . . . . . | 4·53 |
| Calcium sulphate, $CaSO_4$ . . . . | 2·51 |
| Calcium carbonate, $CaCO_3$ . . . | 21·75 |
| Alumina, $Al_2O_3$ . . . . . . | 10·65 |
| Ferric oxide, $Fe_2O_3$ . . . . . | 33·49 |
| Magnesia, $MgO$ . . . . . | trace |

5. *Cornwall Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 1·40 |
| Water, combined | 10·00 |
| Silica, $SiO_2$ | 59·67 |
| Alumina, $Al_2O_3$ | 9·72 |
| Ferric oxide, $Fe_2O_3$ | 18·54 |
| Calcium oxide, CaO | 0·23 |

6. *French Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 1·80 |
| Water, combined | 9·20 |
| Silica, $SiO_2$ | 54·00 |
| Alumina, $Al_2O_3$ | 13·75 |
| Ferric oxide, $Fe_2O_3$ | 20·73 |
| Calcium oxide, CaO | 0·19 |

7. *South Australian Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 1·82 |
| Water, combined | 6·48 |
| Silica, $SiO_2$ | 41·20 |
| Ferric oxide, $Fe_2O_3$ | 38·40 |
| Alumina, $Al_2O_3$ | 12·56 |

8. *American Ochre :—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 1·30 |
| Water, combined | 3·70 |
| Alumina, $Al_2O_3$ | 4·06 |
| Ferric oxide, $Fe_2O_3$ | 11·03 |
| Silica, $SiO_2$ | 4·47 |
| Barium sulphate, $BaSO_4$ | 75·39 |
| Calcium carbonate, $CaCO_3$ | trace |

The chemical composition is of no value for determining the actual value of an ochre as a pigment. For instance, the proportion of oxide of iron (although the colour depends upon its presence) is no criterion of the depth of colour or brightness, as much depends upon the condition of the oxide. The best ochres contain it in a highly hydrated form, and possess brightness as well as depth of colour. Other ochres contain the anhydrous oxide and have a reddish tint, which is rather objectionable. Then the covering power and body of an ochre greatly, if not entirely, depends upon the condition of the silica, clay, etc., which may be present. If these are in a very fine, amorphous physical condition, then the pigment will be a good one, and will probably have all the qualities of a fine pigment in a high degree. On the other hand, it may be that the constituents of an ochre are in a crystalline condition. In which case they may cause the ochre to lack the opacity required in a first-class pigment in order to give it good covering power and body.

Although, as may have been inferred from what has been said above, ochres vary very much in their strength of colouring power, in their body and in their covering power; they are excellent pigments, working well with all vehicles and with all other pigments, and being durable and permanent under all conditions of exposure to air, light, etc.

They possess the following chemical properties: They are insoluble in water and alkaline solutions and in dilute acids. They are decomposed when treated with strong hydrochloric or nitric acid, the iron, alumina, calcium, etc., forming a yellow solution, while the silica, barium sulphate, and other insoluble constituents form a white or greyish residue. When heated ochres lose their water of hydration, the oxide of iron passing into the anhydrous condition; at the same time the colour changes to red, the intensity or depth of which depends upon the duration and intensity of the heat applied. A short time or a low temperature produces a light red tint, while a longer time or a higher temperature gives a dark red shade. This property is taken advantage of in the preparation of Venetian and Indian reds. See *Indian Red*, *Venetian Red*.

Ochres ought to be tested for strength of colouring power, tint, covering power and body by the usual tests, as given under *Testing Pigments*.

It is rarely that a chemical analysis of ochre is required; if so, a qualitative analysis should first be made according to the ordinary rules of chemical analysis as described in Prof. A. H. Sexton's *Qualitative Analysis* and similar works The constituents thus found will regulate the method for conducting a quantitative analysis.

The following is an outline of a scheme suitable for the great majority of ochres :—

1. *Water.*—This is usually present in two forms, as will be seen from a consideration of the analyses of ochres given above ; hygroscopic water and water of hydration or combination. To determine the amounts of these weigh a small porcelain crucible and place in it 2 grammes of the sample of ochre, which has been previously very finely powdered, and apply heat for about half an hour on a sand bath over the Bunsen burner ; then allow the crucible and its contents to cool (best in a dessicator), and weigh. The loss of weight is that of the *hygroscopic water*. Next take the crucible and place it on a pipe tube triangle over a Bunsen burner and heat strongly to a bright red heat for half an hour, then allow the crucible to cool and re-weigh. This second loss of weight gives the amount of *water of hydration*. An actual example will show this :—

| | Grammes. |
|---|---|
| Weight of crucible and ochre . . . . | 8·260 |
| Weight of crucible . . . . . . | 7·260 |
| Weight of ochre . . . . . . | 1·000 |

| | Grammes. |
|---|---|
| Weight of crucible and ochre before drying . | 8·260 |
| Weight of crucible and ochre after drying . | 8·247 |
| Loss of weight . . . . . . . | ·013 |

Per cent. of hygroscopic water, 0·013 × 100 = 1·3.

| | Grammes. |
|---|---|
| Weight of crucible and ochre before heating . | 8·247 |
| Weight of crucible and ochre after heating . | 8·210 |
| | ·037 |

Per cent. of water of hydration = 3·7.

2. *Insoluble Matter.*—A fresh portion (1 to 2 grammes) of the ochre is weighed out into a beaker and heated strongly with hydrochloric acid, until the insoluble portion appears to be white and free from iron. Then filter this off and wash the residue on the filter with hot water, adding the washings to the filtrate and collecting them all. The filter and its contents are dried, burnt in a weighed porcelain crucible, allowed to cool and then weighed. This gives the weight of the *insoluble residue*. This residue will probably consist of silica, barium sulphate or other insoluble substances. It is not needful generally to make a further analysis of it. By boiling with a strong solution of sodium carbonate the silica may be separated from the barium sulphate. An ochre examined by the author gave the following figures:—

| | Grammes. |
|---|---|
| Weight of crucible and insoluble residue . | 8·061 |
| Weight of crucible . . . . . . . | 7·260 |
| Weight of insoluble residue . . . . . | ·801 |
| Less weight of filter paper ash . . . . | ·0024 |
| Weight of insoluble residue . . . . . | ·7986 |

·7986 × 100 = 79·86 per cent. of insoluble matter.

3. *Iron.*—To the filtrate from the insoluble matter add ammonia in slight excess and filter off the precipitate of the hydroxides of iron and alumina obtained ; wash this precipitate and retain the filtrate and washings. Dissolve the precipitate in hydrochloric acid and add an excess of caustic soda solution to the solution and boil for a short time. Filter and well wash the precipitate, adding the first washings to the main body of the filtrate ; then dry, burn the precipitate in a weighed crucible and weigh it. This gives the weight of *iron oxide* in the ochre. An example is given in the following figures :—

| | Grammes. |
|---|---|
| Weight of crucible and iron oxide . . . . | 7·375 |
| Weight of crucible . . . . . . . | 7·260 |
| | ·115 |
| Less filter ash . . . . . . . . . | ·0047 |
| Weight of iron oxide . . . . . . | ·1103 |

0·1103 × 100 = 11·03 per cent. of iron oxide in the ochre.

4. *Alumina.*—To the filtrate from the precipitate formed by caustic soda, add sufficient hydrochloric acid to neutralise the alkali and then sufficient ammonia to precipitate the alumina ; this precipitate is filtered, washed, dried, burnt and weighed. The following figures are given as an example :—

| | Grammes. |
|---|---|
| Weight of crucible and alumina . . . . | 7·320 |
| Weight of crucible . . . . . . . | 7·260 |
| | ·060 |
| Less weight of filter ash . . . . . . | ·0094 |
| | ·0506 |

0·0506 × 100 = 5·06 per cent. of alumina in ochre.

5. *Calcium.*—To the filtrate from the ammonia precipitate of iron and alumina add a little ammonium oxalate. This will, if calcium be present, throw down a white precipitate of calcium oxalate, which is collected, washed, dried, burnt and weighed, the residue in the crucible being calcium carbonate. Multiplying the weight of this residue by 0·56 gives the weight of *calcium oxide* equal to it.

For other constituents that may occasionally be present in ochres the analyst is referred to works on *Quantitative Chemical Analysis*, such as that of Prof. Humboldt Sexton.

For further information respecting ochres reference may be made to the author's *Manual of Painters' Colours.*

**OILS.**—A class of important bodies derived from the animal, vegetable and mineral kingdoms. Oils as a class are non-volatile, liquid bodies, lighter than water, and viscid in nature, not volatile; they impart a greasy and permanent stain to paper, and are smooth and unctuous to the feel. Oils are divided into two great divisions, the fatty oils and the hydrocarbon oils. The fatty oils are derived solely from the animal and vegetable kingdoms, every animal and every plant yielding more or less oil. Many of them, as tallow, palm oil, olive oil, lard, whale oil, are valuable commercial products. The hydrocarbon oils are derived from certain kinds of shale (from which circumstance has arisen their name of mineral oils) and from petroleums, products which are found in large quantities in various portions of the globe.

The characteristics of the fatty oils have already been noted under *Drying Oils.* The hydrocarbon oils are almost entirely employed for lubricating machinery and for illuminating purposes. They have few, if any, applications in painting. Sometimes products derived from shale and petroleum are used in paint and varnish making. These will be found described under *Benzoline* and *Shale Naphtha*. The hydrocarbon oils are sometimes found in linseed oils as adulterants. Their principal characteristic is that caustic soda or caustic potash has no action on them, and hence they are often called *unsaponifiable oils* to distinguish them from the fatty animal and vegetable oils which *are saponified* by either caustic soda or caustic potash.

**OLEFINES** form a group of hydrocarbon compounds in which the carbon and hydrogen are present in the ratio of one of carbon to two of hydrogen, and the general formula for which is $C_nH_{2n}$. The series is a large one, comprising some sixteen to twenty members, and extending from ethene or ethelene, $C_2H_4$ (the lowest of the series), to hexdecene, $C_{16}H_{32}$, and a few others. They are of importance as forming the chief portion of the lubricating oils obtained from Scotch shale and American petroleum. The olefines are characterised by the following properties: They are unattacked by alkalies. Acids have but little action on them. Long-continued digestion with strong sulphuric acid converts them into sulphuric acid compounds of the paraffin series of hydrocarbons. They combine with bromine and iodine to form additive compounds. They have no direct affinity for oxygen, and do not readily form oxygen compounds.

**ORANGE LAKE.**—Orange lakes are chiefly made from coal tar colouring matters. No simple orange lake from a natural dyestuff is known, but mixtures of lakes made from cochineal and Persian berries have been sold under the name of orange lake.

**ORANGE LEAD.**—This pigment is made from white lead, more especially from the scum which collects on the tops of the tanks in which white lead is being washed. White lead, when heated in a furnace to which air has access, loses carbonic acid and water, and takes up oxygen and thereby passes into orange lead, as shown in the following equation :—

$$2PbCO_3, PbH_2O_2 + O = Pb_3O_4 + H_2O + 2CO_2.$$

Orange lead has a bright scarlet red colour, and is rather heavy, its specific gravity being 6·95. It is an oxide of lead having the composition corresponding to the formula $Pb_3O_4$, in which respect it is identical with red lead. As a pigment it is largely used. It mixes very well with linseed oil, taking from 8 to 9 per cent. thereof to grind into a stiff paste. It exerts a powerful drying action on the oil ; hence paint made from orange lead dries very quickly. On account of this drying action orange lead is sometimes added to paint as a drier, where its colour is not objectionable. It has good colouring powers, body and covering power, and is capable of resisting all ordinary atmospheric influences, although, like all lead pigments, it becomes discoloured when brought into contact with sulphur compounds.

Orange lead when heated becomes dark, but the scarlet colour returns on cooling. Heated with dilute acids, orange lead turns a dark brown colour, due to its decomposition into lead dioxide (which is insoluble in the dilute acid), and into lead monoxide (which is dissolved by the acid, forming the corresponding lead salt). Heated with strong nitric acid it is gradually dissolved, a colourless solution of lead nitrate being obtained. Heated with strong hydrochloric acid, chlorine is evolved and lead chloride formed. Sulphuric acid converts it into lead sulphate, oxygen being evolved. The presence of adulterants is detected by the presence of an insoluble residue on treatment with acids, and the formation of coloured solutions. The amount of lead in a sample of orange lead can be ascertained by dissolving two grammes in nitric acid, adding a little dilute sulphuric acid (to throw down the lead as sulphate), filtering the sulphate off, washing well with water, then drying, igniting and weighing the lead sulphate. The weight of this multiplied by 0·955 gives the amount of orange lead in the sample.

**ORR'S WHITE.**—This white pigment, discovered and patented by Mr. J. B. Orr in 1874, contains zinc sulphide, $ZnS$, together with zinc oxide, $ZnO$, and barium sulphate, $BaSO_4$. Since its introduction it has come largely into use on account of its many excellent qualities. Other inventors have patented similar pigments (Griffiths, Knight), but practically all the white pigments of this class are now made on the terms of Orr's patent. The process of manufacture consists in first preparing barium sulphide by heating the natural barytes with charcoal in a suitable furnace, the calcined mass being then lixiviated with water to dissolve out the barium sulphide from unchanged barytes and charcoal. On adding this solution to one of zinc sulphate, a combined precipitate of zinc sulphide and barium sulphate is obtained, then by carefully drying and heating this precipitate in a furnace some of the zinc sulphide is converted into zinc oxide.

Pigments so prepared are sold under the names of Orr's white, Charlton white, Lithophone, Griffiths' white, etc. When well made they are pigments which, in their good white colour, excellent body and covering powers, rival, if, indeed, they do not surpass, white lead. They mix well with all kinds of vehicles, are perfectly permanent when exposed. to light and air, and have the great advantage over white lead, in not turning black with sulphuretted hydrogen or sulphur compounds. They are greatly used in preparing enamel paints and varnishes.

Orr's white and similar pigments consist of barium sulphate, zinc sulphide and zinc oxide. The following analysis made by the author will show the average composition:—

| | Per Cent. |
|---|---|
| Barium sulphate, $BaSO_4$ | 69·91 |
| Zinc sulphide, $ZnS$ | 14·70 |
| Zinc oxide, $ZnO$ | 13·33 |
| Water | 2·06 |

It may be pointed out that the barium sulphate in this class of pigments is not present in its natural form of barytes, which, as is well known to painters, is somewhat deficient in body and covering power, but in the form of precipitated barium sulphate, which is of a fine white colour, and has good body and covering powers.

Orr's white and similar pigments may be distinguished by the fact that they give off sulphuretted hydrogen when treated with an acid. Further, when the acid solution is filtered from the insoluble barium sulphate, and treated successively with ammonia and ammonium sulphide, a white precipitate of zinc sulphide is obtained.

Orr's white, Lithophone, Griffiths' white, and similar white pigments, are liable to vary somewhat as regards their degree of whiteness, covering power, body, etc. They should be assayed for these according to the methods described under the heading *Testing Pigments*.

It is rarely that a chemical analysis is required, but when that is the case the following scheme may be employed:—

For *Barium Sulphate.*—Weigh out 2 grammes of the sample, stir it in a little water, add strong hydrochloric acid and heat gently; when all action has ceased, the mixture is diluted with water, the insoluble barium sulphate filtered off, washed with a little water, the washings being added to the filtrate, then dried, ignited and weighed.

For *Zinc.*—Take the filtrate from the barium sulphate and add, in slight excess, ammonia and ammonium sulphide; allow the mixture to stand over night to ensure complete precipitation of the zinc; then filter, wash well, dry, burn and weigh in the usual manner. The residue in the crucible will be zinc oxide.

For *Zinc Sulphide.*—Weigh out 2 grammes of the white and heat them in a mixture of one part of hydrochloric acid with one part of nitric acid; this converts all the zinc sulphide into zinc sulphate. The insoluble portion is filtered off as before, and barium chloride, added to the filtrate, whereby a white precipitate of barium sulphate is formed; this is collected on a filter, washed, dried and burned. The weight of zinc sulphide corresponding to this barium sulphate can be calculated by multiplying it by 0·416, and the corresponding quantity of zinc oxide by multiplying by 0·348; if this quantity be deducted from the total zinc oxide first found, the difference gives the quantity present in the sample as zinc oxide.

**OXIDE REDS.**—A group of red pigments which owe their colour to ferric oxide. They are known by a variety of names, Indian red, Venetian red, light red, Turkey red, oxide red, scarlet red, rouge, colcothar, etc. In some cases they consist of ferric oxide only, when as a rule they have a deep red colour and possess strong colouring and covering powers and body. In other cases the ferric oxide is mixed with other constituents, calcium sulphate, barium sulphate, silicate of alumina, etc., depending upon the sources of the raw material of which the red is made and on the process of manufacture. Some of these have been already described; others will be found in their proper places. Oxide reds are noted for their permanence and durability. The term oxide reds is often applied to those which are prepared artificially, usually by precipitation of iron solutions. They often contain sulphate of calcium.

**OZOKERIT.**—This substance is a waxy material found naturally in many places. The great bulk of the ozokerit of commerce comes from Boroslav in Silesia, where it is mined. The crude material is boiled with water, when the wax collects at the top and the earthy impurities fall to the bottom. The wax is then run into moulds and is cast into blocks. Crude ozokerit is a black waxy material, melting at about 140° to 150° F. It is rarely used in that form, but undergoes a process of purification. Two processes are employed in purifying ozokerit. In one the crude ozokerit is put into stills and distilled with the aid of fire and superheated steam, two or three products being obtained: (1) a soft buttery material; (2) a hard waxy material, the refined ozokerit of commerce, which can be bleached to a good white colour; and (3) a black pitchy residue, which is employed as an insulator in electrical work. Another method of refining consists in treating the crude ozokerit with strong sulphuric acid, either with or without the addition of bichromate of potash. This destroys the colour of the crude mass, and, after thoroughly washing with water, yields ozokerit having a yellow colour (which is rather difficult to destroy) and a granular appearance. This variety is commonly known as *ceresin*.

Ozokerit resembles paraffin wax in its composition; in fact, it is a mixture of the higher members of the paraffin series of hydrocarbons. It usually melts at 140° F. to a limpid fluid. It is unacted upon by acids and alkalies. It is combustible, burning with a bright flame and forms an excellent candle material.

Ceresin is largely employed as a substitute for beeswax, which it closely resembles in appearance and properties.

## P.

**PARAFFIN.**—This name was first given to a white, solid waxy substance obtained by Reichenbach from beechwood tar. Since then it has been applied to a number of products obtained in the distillation of Scotch shale; hence the term *paraffins* has been applied to a series of hydrocarbon compounds possessing the same general properties as the original paraffin. At present whenever the term paraffin is employed by itself it is generally understood to refer to the solid wax, but it is rarely used by itself.

**PARAFFIN OIL.**—This product is the second lightest body obtained in the refining of the crude oil distilled from Scotch shale. It is a light limpid liquid of a water-white colour, having a specific gravity of 0·810 to 0·820. It evaporates slightly when exposed to the air. It is inflammable, burning with a luminous flame, and hence is chiefly used for illuminating purposes. The flashing point of paraffin oil ranges from 105° F. to 150° F., when tested in the Abel apparatus. The fire test ranges from 120° F. to 170° F. Paraffin oil is a mixture of several members of the paraffin and olefine series of hydrocarbons, and of course partakes of the properties of those compounds. It is used occasionally in the preparation of boiled oil substitutes.

**PARAFFIN SHALE.**—This is the raw material used in the manufacture of paraffin oil, wax, etc. It is found in the south-west of Scotland, in the district between Glasgow and Edinburgh, and at several places is mined in the same manner as coal. The shale is placed in large upright retorts and distilled, the products being an uncondensable gas, which is used for fuel and illuminating; water containing ammonia, used in making sulphate of ammonia; and a thick tarry oil which is known as "crude oil". This latter substance is subjected to repeated distillations and treatment with sulphuric acid and soda, by which it is refined into several products: naphtha, used in making paints and varnishes (see *Shale Naphtha*); paraffin oil, used for burning in lamps; lubricating oils: and paraffin wax.

**PARAFFIN WAX.**—This valuable product is procured from the crude oil obtained in the distillation of paraffin shale. The crude oil is distilled. The lighter portions (yielding the naphtha and burning oils) are separated and the heavier portions (containing the solid paraffin) are cooled with the aid of refrigerating machines. The solid paraffin crystallises out and is separated from those by means of filter presses. It is then subjected to purification, by means of which grades of wax are obtained, the melting points of which range from 108° F. to 135° F. Paraffin wax is also obtained by a similar process from the heavier portions of American petroleum.

Paraffin wax is a white or yellowish waxy-looking solid, varying in consistency and in the temperature at which it melts. In commerce the melting point regulates the quality. The usual grades are 108° F., 110° F., 120° F., 125° F., and 130° F. The wax melting at 108° is soft, but the others are much harder and emit a somewhat metallic ring when struck. When heated paraffin wax melts to a thin, limpid liquid, and expands considerably. It is unacted on by acids, even strong ones, at the ordinary temperatures, but at higher temperatures strong nitric acid and strong sulphuric acid have some action. Alkalies, whether in weak or strong solution, have no action. These properties give to paraffin wax an importance not possessed by other substances. It is used for a variety of purposes, such as candle making (for which it is the chief substance now used), electrical work, etc.

**PARAFFINS.**—These form a group of hydrocarbons deriving their importance on account of their being present in American petroleum and Scotch paraffin oils. They are compounds of carbon and hydrogen, containing the two elements in the ratio, $C_nH_{2n} + 2$. There is a very complete series of over twenty members, ranging from methane or marsh gas, $CH_4$, to the solid paraffin waxes, whose exact composition is not known with certainty, but which probably approximates to the formula, $C_{20}H_{42}$. The lower members of the series are gaseous; then, as the complexity of the molecule becomes greater, they are liquids varying in specific gravity and boiling point. While the highest members are solid bodies and constitute the paraffin waxes, the lighter liquid members form the great proportion of the shale and petroleum naphthas and benzolines. The next heavier members, the petroleum and paraffin burning oils (although the heaviest of the liquids) are found in the lubricating oils obtained from the two sources just named.

The paraffins are characterised by the following general properties: They are unacted upon by acids and alkalies at the ordinary temperature. Nitric acid when heated with them oxidises them to a small extent. Chlorine acts slowly, producing substitution products, while iodine and bromine have a very feeble action. From the products thus formed a series of bodies, known as alcohols, can be prepared by the action of alkalies, and these alcohols, by treatment with oxidising agents, can be transformed into acids belonging to the acetic series of fatty acids.

The consideration of the chemical relations of the paraffins belongs to a book on *Organic Chemistry*, to which the reader may be referred. A full account will also be found in Mr. Boverton Redwood's *Treatise on Petroleum*.

**PARIS BLUE.**—Ultramarine, Prussian blue and aniline blue, are sold under this name. See *Prussian Blue*, *Ultramarine*.

**PARIS GREEN,** the American name for Emerald green.

**PARIS WHITE,** the name usually assigned to the best qualities of whiting. See *Whiting*.

**PATENT DRIERS.**—This name has been applied to commercial preparations sold in the form of a paste for the purpose of using as a drier for paints and varnishes. The following is an example: 15 lb. of dried zinc sulphate, 4 lb. of lead acetate, 7 lb. of litharge ground with 8 lb. of boiled oil; to this mixture is added 100 lb. of Paris white, 50 lb. of white lead, and sufficient boiled oil to make the whole into a stiff paste. In some patent driers the zinc sulphate is replaced by dried ferrous sulphate with advantage.

**PATENT YELLOW.**—This pigment, also known as Turner's yellow, is a basic oxychloride of lead, prepared by digesting salt, litharge and water, for some days, and then calcining the mixture. It is now made in small quantities only, having been replaced by the chrome yellows.

**PATTINSON'S WHITE LEAD** has gone out of use. It was essentially a basic chloride of lead, prepared by treating chloride of lead with lime.

**PERSIAN RED.**—Under this name have been sold bright reds made from oxide of iron, as also the basic chromate of lead. See *Derby Red* and *Antimony Vermilion*.

**PETROLEUM** is an oily liquid, found naturally in large quantities in North America, the Caucasus, Burmah, and other localities. It varies considerably in quality, from a pale light oil to a thick tarry mass. It is beyond the scope of the present work to enter into details, for which reference should be made to Mr. Boverton Redwood's *Treatise on Petroleum*. The crude petroleum is refined by a process of fractional distillation, and by treatment with sulphuric acid and caustic soda into a variety of valuable products, the nature of which depends upon the character of the crude petroleum. From North American petroleum is obtained *gasoline*, which is a very light liquid of about 0·660 specific gravity, used chiefly for carburetting air and illuminating gas; *benzoline*, which has a specific gravity of from 0·730 to 0·760, employed as a solvent in making paints and varnishes; *kerosene*, or burning oil, made in various grades, having a specific gravity ranging from 0·792 to 0·815; *lubricating oils*, ranging from 0·865 to 0·915; *cylinder lubricating oils*, of a very viscid nature, and in some cases of a blackish-brown colour; *vaseline*, a soft, buttery mass, of great use in medicine; and *paraffin wax*. Russian petroleum oil yields naphtha in small quantity, burning oils of various grades, and lubricating oils; but no wax, vaseline, or cylinder oils. The petroleum products, met with in commerce in this country are mostly from North American and Russian crude petroleums; those from other localities are rarely met with.

Petroleum is a complex mixture of various hydrocarbon compounds, chiefly belonging to the series of paraffins and olefines, of which nearly the whole series have been found in American petroleum and in other petroleums. The Caucasian petroleum differs from the American in yielding naphthenes, not paraffins and olefines. In its general properties, therefore, it partakes of the properties of these hydrocarbons which have already been detailed. See *Olefines, Paraffins.*

**PETROLEUM NAPHTHA or PETROLEUM SPIRIT.**—This product is a limpid, water-white liquid (having a specific gravity ranging from 0·730 to 0·760), obtained in the refining of crude American petroleum. It is also known as benzoline. See *Benzoline,* and Translation of Neuburger and Noalhat's *Technology of Petroleum.*

**PHOSPHATE OF SODA.**—See *Sodium phosphate.*

**PIPE CLAY.**—A white clay having a composition similar to china clay; very soft and greasy to the touch, and very tenacious. It is largely used in making tobacco pipes; hence its name of pipe clay.

**PLASTER OF PARIS.**—This substance is the anhydrous calcium sulphate, $CaSO_4$. It is prepared by grinding and heating natural gypsum in a furnace, so as to drive off its water of crystallisation. The material is then ready for use. The various qualities presented by plaster of Paris are due to differences in the degree of grinding, care in calcining and in sieving. Plaster of Paris owes its value to the property it possesses of absorbing water and passing into the hydrated condition, in doing which it sets into a hard mass. This setting takes place quickly, but a sufficient time elapses between mixing it with the water and setting to permit the mass to be run into moulds or used for coating surfaces, so that it may be made into ornaments of various kinds, or it may be used as a cement. Plaster of Paris should be kept in a dry place, as it readily absorbs moisture and so loses its property of setting. When plaster of Paris has been used its property of setting may be recovered by re-heating it, but generally such re-heated plaster is not equal to the original in quality. Precipitated calcium sulphate does not set in the same way as plaster of Paris.

For the chemical properties of plaster see *Gypsum*.

**POPPY SEED OIL.**—This oil is obtained from the seeds of the poppy plant (*Papaver somniferum*), either by pressure, or by means of solvents. It is a very good drying oil, equalling linseed oil in this respect. It is, however, not much used, being more costly than linseed. Artists are the only persons who make much use of it. Poppy oil is usually of a pale straw colour, very limpid, has little or no odour, when fresh, and a pleasant taste. The specific gravity ranges from 0·924 to 0·927. It remains fluid at low temperatures, the solidifying point being – 18° C. It is soluble in about twenty-five times its volume of cold alcohol, and in four times its volume of boiling alcohol. Strong sulphuric acid mixed with the oil causes a considerable rise, 88° to 90° C., in temperature. It takes about 19 per cent. of caustic potash to saponify it. It absorbs 134 to 137 per cent. of iodine.

**POTASSIUM** is one of the alkali metals; its symbol is K, from the Latin *kalium*, and its atomic weight 39. The potassium salts are very useful compounds, many of them (the carbonate, nitrate, chlorate, bichromate, ferrocyanide, etc.) being used in large quantities in many industrial operations. Potassium is a silver-white metal, and very soft, being easily cut with a knife; on exposure to the air it rapidly oxidises, owing to the great affinity it has for oxygen. Thrown into water, it decomposes that body with so much energy that the hydrogen which is evolved takes fire. The potassium salts are characterised by their solubility in water; none are insoluble, the least soluble being the platino-chloride and the acid tartrate. Only those compounds of potassium which are employed in the colour trades will be noticed in this book.

**POTASSIUM BICHROMATE.**—It is commonly known as bichrome. See *Bichromate of Potash.*

**POTASSIUM FERRICYANIDE.**—This compound contains the four elements, potassium, iron, carbon and nitrogen, in the proportions indicated by the formula $K_3FeC_6N_6$. The last three elements are very intimately united together to form an acid radicle. This substance is obtained by the action of chlorine on potassium ferrocyanide (see *Potassium Ferrocyanide*), and occurs in large ruby-red crystals which are soluble in water. The solution in water should not give any blue colouration, or precipitate with ferric chloride; such would indicate admixture with potassium ferrocyanide. It is readily soluble in water, requiring about four times its weight for solution which has a greenish colour. Potassium ferricyanide gives with ferrous salts a deep blue precipitate of Turnbull's blue. It is occasionally employed in the preparation of certain shades of Prussian blues. It is used in calico printing and dyeing.

**POTASSIUM FERROCYANIDE,** more generally known as yellow prussiate of potash, is prepared by heating a mixture of animal organic matter with potash in iron vessels, lixiviating the calcined mass and crystallising the prussiate from the liquors thus obtained. Potassium ferrocyanide forms large transparent yellow crystals, having the composition corresponding to the formula, $K_4FeC_6N_63H_2O$. The crystals dissolve in four times their weight of cold and twice their weight of hot water; but are insoluble in alcohol. When gently heated it loses its water of crystallisation; if strongly heated a variety of products are obtained, such as potassium cyanide, potassium cyanate, iron carbide, etc., according as air is or is not excluded. When heated with dilute sulphuric acid it yields hydrocyanic acid; if heated with strong sulphuric acid it is completely decomposed, carbonic oxide being evolved.

A solution of potassium ferrocyanide gives with ferrous salts a bluish-white precipitate; with ferric salts a deep blue precipitate of Prussian blue. The precipitate with ferrous salts is not a stable one, as on exposure to the air it gradually turns a deep blue owing to the formation of Prussian blue. The same change of colour also occurs when the precipitate is treated with chlorine, nitric acid or other oxidising agents. With solutions of copper a brown precipitate of copper ferrocyanide is obtained; with lead a white precipitate of lead ferrocyanide.

Potassium ferrocyanide is largely used for the preparation of Prussian blue, in dyeing and calico printing, and in iron working.

**POTASSIUM HYDROXIDE.**—The chemical name for caustic potash, having the formula, $KOH$. See *Caustic Potash*.

**POTASSIUM NITRATE.**—This compound is found naturally in small quantities. It is prepared on a large scale for the purpose of making gunpowder, nitric acid, and for other purposes. It is a white, crystalline salt with a pleasant saline taste, very soluble in water. When heated, it parts with some of its oxygen, passing into the nitrite of potash. When heated with carbonaceous bodies it loses all its oxygen with great avidity, the mixture burning, with the evolution of considerable heat and fume. It is upon this property that the use of potassium nitrate for making gunpowder and pyrotechnical mixtures is based. It is employed as an oxidising agent in some chemical operations. Its chemical formula is $KNO_3$.

**POTTER'S LEAD ORE** is galena, the natural sulphide of lead, having the formula PbS, and occurring in greyish lustrous masses. It is employed in the pottery trades for the production of glazes. Galena is found in highly lustrous masses of a crystalline tendency, which readily break up into cubical pieces. It contains 13·4 per cent. of sulphur and 86·6 per cent. of lead. It is heavy, the specific gravity ranging from 7·25 to 7·7. When heated in a closed tube, it gives off sulphur; when strongly heated in a current of air, part is converted into lead sulphate, part into oxide, while some of the sulphur escapes as sulphur dioxide. When heated with carbon or carbonaceous matter it is reduced to the metallic condition. Fused with silicates it forms an easily fusible lead silicate, on which property its use in pottery making is based.

**PRUSSIAN BLACK.**—When Prussian blue is heated in a closed vessel, it leaves the black residue formerly sold under the name of Prussian black. It is essentially a mixture of carbon and ferric oxide. It is not now made.

**PRUSSIAN BLUE.**—This is one of the most valuable blues known. It is prepared by precipitating solutions of iron salts by means of solutions of potassium ferrocyanide (yellow prussiate of potash) or of potassium ferricyanide (red prussiate of potash). It is essentially a compound of iron, carbon and nitrogen. The iron is, however, present in two conditions. In one it is as a base; while in the other it is in intimate union with the carbon and nitrogen to form an acid radicle known as ferrocyanogen or ferricyanogen. The exact chemical composition of Prussian blue varies slightly with the materials employed in its manufacture. In some cases it is ferric ferricyanide, having the formula, $FeFeC_6N_6$; and in others potassium ferric ferrocyanide having the formula, $K_2FeFeC_6N_6$, for it is rather difficult to entirely remove alkali from the precipitate, especially when potassium ferrocyanide and ferrous sulphate are employed in making it.

There are many varieties of Prussian blue. The best quality is known as *Chinese blue*, and is remarkable for its bronzy appearance, its strength of colour and solubility in oxalic acid. The name of *Prussian blue* is given to a blue somewhat poorer in quality than Chinese blue. *Paris blue* is a Prussian blue of a more violet tone than either of the two above named. *Paste blue* is, as its name indicates, in a paste form, containing from 25 to 30 per cent. of actual colour and from 70 to 75 per cent. of water. *Soluble blue* is a variety which is easily soluble in water, yielding a deep blue solution. *Brunswick blue* is a mixture of Prussian blue and barytes. *Antwerp blue* has gone out of use. It is a light-shade blue prepared by precipitating mixtures of ferrous sulphate, alum and zinc sulphate with potassium ferrocyanide. *Steel blue* or *Mitis blue* is a fine tint of Prussian blue resembling ultramarine. For a full description of the methods of making these the reader is referred to the *Manual of Painters' Colours*.

Prussian blues have the following properties: With the exception of the soluble blue they are insoluble in water, but they have so fine a texture that they appear to be dissolved when mixed with water. They are insoluble in acids, either strong or dilute. If boiled with strong acids they undergo decomposition, hydrocyanic acid being given off. When boiled with solutions of caustic soda, or of potash, or with ammonia, the blue is decomposed, a brown insoluble mass of ferric hydroxide being formed, while the solution contains ferrocyanide or ferricyanide of the alkali. This reaction is characteristic of Prussian blues, no other pigment giving the same result. The alkaline solution on neutralisation with an acid will, on addition of ferrous sulphate, give a blue precipitate of Prussian blue. When heated in a crucible exposed to the air Prussian blue is decomposed and a dark red residue (consisting chiefly of oxide of iron mixed with carbon) is obtained.

Prussian blue mixes well with either oil or water and all other vehicles, except such as are of an alkaline nature. It cannot, therefore, be used with lime or silicate of soda, as these turn it brown. It may be mixed with all other pigments without being changed or producing any change in them. It is a fairly permanent pigment when exposed to air and light. It possesses the curious property of fading somewhat when exposed to light, and of regaining its original colour in the dark. Prussian blue is remarkable on account of its strong colouring powers. It is, however, somewhat transparent, and therefore does not cover well.

Prussian blues, on account of their difference in tint, colouring power, etc., should be assayed for those properties in the usual way. It is rarely that a chemical analysis is required. If it is, the following hints will be found useful :—

**Paste Blues.**—It is often desirable to test these for the proportion of actual colour. This can be done by weighing 2 grammes into a porcelain basin and heating this in the air bath to a temperature not exceeding 105° C. until it ceases to lose weight between two successive re-weighings of the sample.

*To estimate the amount of actual Prussian blue in any sample of blue pigments containing it :* Weigh out 2 grammes, boil with a weak solution of caustic soda until the pigment is thoroughly decomposed ; then filter and wash well ; next treat the residue with hydrochloric acid until the residue is completely dissolved (which will happen if the blue is pure) or a white residue is left. To the hydrochloric acid solution add ammonia in slight excess to re-precipitate the iron; filter off this precipitate, wash it with water, dry it, burn it in a weighed crucible, and weigh the residue of ferric oxide which is obtained. By multiplying this weight by 2·212 the weight of the Prussian blue in the sample may be ascertained. The filtrate from the caustic soda solution will contain any alumina or zinc which may have been mixed with the blue. The presence of these may be ascertained by neutralising the solution with hydrochloric acid, then adding, first, ammonia (which will throw down a white precipitate of alumina, if present); then ammonium sulphide (when a white precipitate of zinc sulphide will be obtained, if that meta be present). In the case of Brunswick blues which contain barytes or gypsum, such will be left as an insoluble white residue on treatment with hydrochloric acid, after decomposing the pigment with caustic soda.

**PRUSSIAN BROWN.**—This name has been given to the brown pigment obtained by heating Prussian blue at a comparatively low temperature. It is obsolete.

**PRUSSIAN GREEN** is a mixture of Prussian blue with either chrome yellow or gamboge.

**PRUSSIATE BLACK** is the black residue obtained in the manufacture of prussiates of potash. After being washed with water the partially dried black is chiefly employed for decolourising paraffin wax, sugar, etc. It is rarely, if ever, employed as a pigment.

The following are some analyses of prussiate black or, as it is sometimes called, prussiate char, made by the writer:—

| | Per Cent. | Per Cent. |
|---|---|---|
| Water | 22·12 | 17·10 |
| Mineral matter | 37·88 | 48·24 |
| Carbon and volatile matter | 40·00 | 34·66 |

The ash contained :—

| | Per Cent. | Per Cent. |
|---|---|---|
| Soluble alkaline salts . . | 10·82 | 20·00 |
| Phosphoric acid . . . | ·58 | ·81 |
| Silica . . . . . . | 5·75 | 5·56 |
| Calcium carbonate, etc. . . | 20·73 | 21·87 |

**PRUSSIATES OF POTASH.**—There are two prussiates of potash. The commonest is the yellow prussiate or potassium ferrocyanide (see *Potassium Ferrocyanide*). The red prussiate is potassium ferricyanide (see *Potassium Ferricyanide*). These salts are largely employed in the manufacture of Prussian blues, Brunswick greens and other pigments, in dyeing and calico printing, etc.

**PUMICE.**—Pumice, as is well known, is of volcanic origin, being a trachytic lava which has been rendered light by the escape of gases when in a molten state. It is found on most of the shores of the Tyrrhenian Sea and elsewhere, but is at present almost exclusively obtained from the little island of Lipari. Most of the volcanoes of Lipari have ejected pumiceous rocks, but the best stone is all the product of one mountain, Monte Chirica, nearly 2,000 feet in height, with its two accessory craters. The district in which the pumice is excavated covers an area of three square miles. It has been calculated that about 1,000 hands are engaged in this industry, 600 of whom are employed in extracting the mineral. Pumice is brought to the surface in large blocks or in baskets, and is carried thus either to the neighbouring village or to the seashore, to be taken there in boats. The supply is said to be practically inexhaustible. Pumice is used not merely for scouring and cleansing purposes, but also for polishing in numerous trades, hence the fact that the powdered pumice exported exceeds in weight the block pumice.

In chemical composition pumice is a double silicate of alumina and potash, resembling the felspars. The following is an analysis:—

| | Per Cent. |
|---|---|
| Silica, $SiO_2$ | 46·58 |
| Alumina, $Al_2O_3$ | 20·00 |
| Ferric oxide, $Fe_2O_3$ | 3·20 |
| Ferrous oxide, FeO | 5·69 |
| Manganese, $MnO_2$ | 1·07 |
| Calcium oxide, CaO | 9·09 |
| Magnesium oxide, Mgo | 3·16 |
| Potash, $K_2O$ | 7·35 |
| Soda, $Na_2O$ | 2·74 |

There is sometimes present other elements, such as titanium, boron, uranium, etc.

The specific gravity of pumice stone powder is about 2·2, but in consequence of the porous character of the masses, these will float on water for some time before they get so water-logged as to sink, the porous character being produced by gases blowing into the mass of pumice when in a molten condition.

Pumice is largely used in the painting and decorating trades for rubbing down old painted work preparatory to repainting, and in rubbing down between one coat and another in coach painting. It is also occasionally used for making what are known as wood fillers.

**PURPLE OXIDE.**—This is an oxide of iron pigment prepared by strongly heating ferrous sulphate or other iron compound. In its properties it resembles the oxide reds. Purple oxide is made in two or three shades, distinguished as light, medium or dark.

**PURPLE OF CASSIUS.**—This is the dark purple or violet precipitate of metallic gold which is obtained when tin crystals are added to a solution of gold in aqua regia. Precipitated gold is used in the pottery and glass trades for gilding. It is usually prepared by precipitating gold chloride by ferrous sulphate or oxalic acid. The gold may also be precipitated by metallic tin. See *Gold Liquid.*

## Q.

**QUARTZ.**—The name given to the crystalline variety of silica. It is found in many forms, sometimes in clear transparent six-sided prisms with pyramidal ends; at others crystalline in structure, but opaque in appearance. It is one of the constituents of granite, and the essential constituent of sands and sandstones. It is very hard, being capable of scratching glass, ranking next to the diamond in this respect. Its specific gravity is about 2·5. It is quite insoluble in all acids except hydrofluoric acid, is unattacked by alkalies at the ordinary temperature, but, when heated with them, is gradually dissolved, an alkaline silicate being formed. It is infusible and is one of the most unchangeable of substances. Quartz is the oxide of the metal silicon, and has the formula $SiO_2$. It is acid in nature and enters into combination with metals to form silicates, those of the alkali metals being soluble in water, all others being insoluble. Some are soluble in acids, others are not so. A great many silicates are found naturally and having a great affinity for one another; a large proportion are double silicates, such as felspar, mica, etc., etc. Glass, pottery and porcelain are silicates of alumina, calcium, lead, etc., prepared artificially.

## R.

**RAW SIENNA.**—See *Sienna.*

**RAW UMBER.**—This pigment is used in its natural state, or, it may be, after purification by lixiviation. See *Umbers.*

**REALGAR.**—An arsenic sulphide, formerly used as a pigment, but now obsolete.

**RED LAKE.**—The name sometimes given to a lake prepared from Brazil wood, or similar red dyewood, by precipitation with alumina. It is very little used now. See *Lakes.*

**RED LEAD** is one of the oxides of lead having the composition indicated by the formula, $Pb_3O_4$. It is a combination of the mon- and dioxides of lead in the proportion indicated below :—

| | Per Cent. |
|---|---|
| Lead monoxide, $PbO$ . . . . | 64·5 |
| Lead dioxide, $PbO_2$ . . . . | 35·5 |

It is prepared by first melting lead and passing a current of air over it whereby it is converted into the monoxide. This is then ground into fine powder and heated in a furnace in a current of air, from which it absorbs oxygen and is converted into the red lead.

Red lead is a very useful pigment. It mixes well with oil and exerts on the latter a strong drying action. A mixture of red lead and linseed oil on exposure to the air sets into a hard mass; hence it is often used as a cement and in the packing of steam joints. It has fairly good covering and colouring powers. When used as a paint it is apt (on account of its high specific gravity) to settle out in the paint can. When exposed to ordinary atmospheric influences it is fairly permanent, but in presence of sulphur or sulphurous gases it turns brownish. It may be mixed with all pigments except those which contain sulphur (such as cadmium yellow, ultramarine). Red lead is largely employed in preparing boiled oil as a dryer. It, however, imparts a dark red brown colour to the oil.

Red lead is a heavy, bright red powder, of an orange hue, its specific gravity being about 8·3. When heated it turns brown, but the original colour comes back on cooling. Acids react with red lead. The first action is to dissolve out the monoxide, leaving the dioxide as a brown residue ; thus dilute nitric acid and acetic acid turn red lead brown. Boiled with nitric acid red lead slowly dissolves, and on adding water a colourless solution of lead nitrate is obtained. Glacial acetic acid also dissolves red lead, forming lead acetate. Hydrochloric acid decomposes red lead, with evolution of chlorine and formation of lead chloride, which separates out on cooling the solution. Sulphuric acid forms lead sulphate, which is insoluble.

*Analysis of Red Lead.*—Red lead should be completely soluble in either nitric or acetic acids. It must be borne in mind, however, that as the lead salts formed are not soluble in strong acid solutions, these must be diluted with water to render the lead soluble. Colourless solutions are obtained. Any yellow colour would indicate the presence of iron, probably as red oxide. Any insoluble residue from the acids will be an adulterant. The solutions obtained should give a white precipitate with sulphuric acid, and on filtering this off little or no further precipitate should be obtained on adding in succession ammonia, ammonium sulphide, and ammonium carbonate.

**RED OCHRE.**—A natural oxide of iron red resembling ochre in its composition. It is found in various places, but is not of much importance. One such sample, found at Speeton in Yorkshire, had the following composition:—

| | Per Cent. |
|---|---|
| Ferric oxide, $Fe_2O_3$ | 9·60 |
| Alumina, $Al_2O_3$ | 1·42 |
| Silica, $SiO_2$ | 9·28 |
| Calcium carbonate, $CaCO_3$ | 80·04 |
| Calcium sulphate, $CaSO_4$ | ·10 |

**RED OXIDE.**—Under this name pigments prepared from iron compounds are sold. Their composition varies somewhat according to the method of making. In some cases they may be pure oxide of iron; in others they contain sulphate of calcium and other substances. It may be mentioned that there is no standard of chemical composition for these reds. Their value as pigments is entirely dependent upon their fineness, opacity, brilliance of colour, strength of colouring power, body and covering power. Their price ranges from £8 to £20 per ton. See *Iron Oxides, Iron Reds.*

**RESINS.**—This name is given to a number of vegetable products, the exudations from many species of trees, which possess the following general properties: They are hard and non-elastic, as a rule, although there are variations in this respect. They are usually homogeneous in structure, more or less transparent, brittle, and insoluble in water. Their solubility in other media is very variable. Some, such as animi and copal, are insoluble in all solvents; others, such as shellac and Manila copal, are soluble in alcohol. Some are soluble in ether, and a few are soluble in petroleum spirit. They are all largely used in the manufacture of varnishes, to which they impart their lustre and substance. They are commonly known as gums.

When resins first exude from the tree they are generally soft in consistence and have a fragrant aromatic odour, due to their containing a small proportion of volatile essential oil. This on exposure to the air gradually evaporates away, leaving the resin as a hard friable mass. In some cases (animi, copal, kauri) this change has been spread over a long period of time. The substances have been buried in the soil and protected from the vicissitudes of the weather, so that the resin has acquired an exceptional degree of hardness. In other resins this hardening action has only proceeded to a small extent; hence several of the commercial products still retain a soft consistence, as gum thus, gum elemi, soft Manila copal, etc.

The resins are acid in composition, but their chemical characters have not yet been fully investigated. When heated they melt at varying temperatures, some below or near the boiling point of water, as shellac, benzoin; while others, animi, copal, require much higher temperatures. When distilled they undergo decomposition—water and, in many cases, a light oily product of a turpentinous character being given off. If the distillation be proceeded with until about 25 to 30 per cent. of the resin has come over, the residue still possesses resinous properties; but has now become soluble in most solvents, oils, etc. On this property the manufacture of animi, copal, kauri and other resins into varnishes is based.

The resins chiefly used in the manufacture of varnishes will be found described under their commercial names or under gums.

**RINMAN'S GREEN.**—The name often given to zinc green. See *Zinc Green.*

**ROSE MADDER.**—A lake pigment prepared from madder by combining it with alumina. It has a pale rose colour, mixes well with oil or water, and has good properties as a pigment. It is fairly permanent. It is used only by artists, being too costly for house painting and decorating.

**ROSE PINK.**—A lake prepared on a base of whiting or some other white pigment from Brazil wood by means of alumina. It is of a pale and somewhat dull colour, with but little body and colouring power. It is fugitive when exposed to light. It is chiefly employed in paper staining and wall-paper printing.

**ROSIN.**—When the resinous exudations from various species of pine trees are distilled with the aid of steam the products are a volatile spirituous substance, turpentine (see *Turpentine*), and a liquid residue which, when it is run off and allowed to cool, sets into a hard solid mass, known in this country as *rosin* and in France as *colophony*.

Rosin comes into the market in the form of large masses generally homogeneous in formation, usually transparent or translucent; the darker varieties are, however, nearly opaque. A good many varieties of rosin are distinguished in commerce. The best quality is known as "window glass". It is pale in colour and quite transparent. Then there is "amber" rosin, which is darker in colour and rather less transparent; "black" rosin is nearly black in colour and opaque. The quality of the rosin depends upon the quality of the crude resin from which it is obtained. "Virgin" resin, which is that first collected, yields the best quality of rosin; while the resin last collected in the boxes yields the poorest qualities.

Rosin is slightly heavier than water, its specific gravity ranging from 1·044 to 1·100. It is hard and brittle, being easily ground to a yellowish-coloured powder having a characteristic rough feel. Its odour is fragrant and peculiar, and is more strongly developed when heated. At about 177° F. (75° C.) rosin softens, and at 212° F. (100° C.) it melts to a thin liquid. At higher temperatures it decomposes, water, spirit and oil being formed (see *Rosin Oil* and *Rosin Spirit*).

Rosin is insoluble in water. It is soluble in boiling alcohol, but, on cooling the solution, crystals of what is called sylvic acid separate out. It is also soluble in amyl alcohol, turpentine, ether, acetone, benzol, coal tar naphtha, and petroleum spirit.

When boiled with aqueous solutions of the caustic or carbonated alkalies it gradually dissolves, forming with the alkalies chemical compounds. It is on this property that the use of rosin in soap making and bleaching is based. Rosin is a mixture of two acid bodies, named pinic and sylvic acids, both having the same composition, $C_{20}H_{30}O_{22}$, but differing in their solubilities in alcohol. Some authorities consider that rosin does not contain a true acid but an acid anhydride, to which the name of abietic anhydride has been given, which, on treatment with alkalies, first takes up the elements of water to form abietic acid, and then enters into combination with the alkali.

Rosin is largely used in the preparation of cheap varnishes, rosin spirit, turpentine or coal-tar naphtha being employed as the solvents; or a species of common oil varnish may be made by melting the rosin, keeping it melted for some time, then mixing it with boiling linseed oil. Such a varnish, however, does not possess the durability characteristic of copal or even kauri varnishes.

It is used for other purposes than paint and varnish making.

Rosin being cheap is not subject to adulteration, but, on the other hand, it is sometimes used for making fictitious samples of other resins.

**ROSIN OIL.**—When rosin is subjected to a process of dry distillation it is decomposed and then yields the following distillates: (1) An acid aqueous liquid; (2) a light spirit, known as rosin spirit (see *Rosin Spirit*); and (3) a heavy viscid oil—rosin oil. The residue in the retort is either a hard carbonaceous coke or a black soft rosin pitch, according to the manner of working the stills. The rosin oil in its crude condition appears as a thick, granular oil, varying a little in appearance, according as to whether the distilling operation is carried on quickly or slowly, and to the period of the operation. Several qualities are recognised, and are known as "hard," "soft," "medium," etc. They are used in that condition chiefly for making greases, because, owing to their acid character, they readily combine with lime, soda and other alkalies. By treating the crude oil, first with sulphuric acid, then with caustic soda, and redistilling, refined rosin oils are made in various qualities, from a dark heavy oil to a pale oil with but little odour. Rosin oil is a very heavy oil, having the highest specific gravity of any known oil. Dark rosin oils, heavier than water, with a specific gravity of 1·015 to 1·02 are made. The more refined oils are rather lighter, and vary from 0·980 to 0·990 in specific gravity.

Rosin oils have a very complex composition. The crude oils contain acid constituents of high molecular weight, ethereal bodies capable of being decomposed by caustic soda, and hydrocarbon oils. The refined oils contain a larger proportion of hydrocarbon bodies; in fact, the paler rosin oils contain very little of the acids and ethers present in the crude oils.

But little, however, is known as to the exact nature of these bodies; probably the hydrocarbons are similar to the naphthenes.

The flashing point of rosin oil is very low. When heated it gives off a vapour below 212° F. The flash point is usually about 320° F.; while the fire point is about 400° F.

Rosin oil has a great degree of viscidity or viscosity at the ordinary temperature. On being heated it loses this and becomes thin and limpid.

The crude varieties of rosin oil when exposed to the air set hard. On this account rosin oil has been offered for, and used as, a paint oil; but its use for this purpose is not satisfactory, because, although in the course of a day or so it will set hard, yet, on further exposure, it again becomes soft and tacky; the addition of driers does not seem to affect the result in any way. Rosin oil has been used as an adulterant for linseed oil. Its effect when thus used is to prevent the oil paint from permanently drying. It is to be noted that the more refined rosin oils do not exhibit any drying properties whatever.

Rosin oil may be distinguished by its odour, bloom or fluorescence, its high specific gravity, its great viscosity and its low flash point; as also by giving off when heated the peculiar odour of burning rosin. Its taste, too, is peculiar. When added to other oils it may be detected by the increase in the specific gravity, by the flash point, and by odour of rosin which is evolved on heating; while the proportion may be approximately ascertained by boiling the sample with caustic soda, separating out the unsaponified portion with petroleum ether, evaporating this off and weighing the residual oil, which is formed of the hydrocarbon constituents of the rosin oil added.

**ROSIN SPIRIT.**—When rosin is distilled in a retort one of the first products to come over is a spirituous liquid, which, when refined (1) by treatment with sulphuric acid and caustic soda, and (2) by redistillation, forms what is known as *rosin spirit.* This body is a water-white or faint yellow limpid liquid, having a peculiar and characteristic odour. Its specific gravity varies from 0·876 to 0·883. It is, therefore, rather heavier than turpentine. When exposed to the air it is volatile. There is, however, a slight tendency to oxidation and to the formation of a resinous residue, as is the case with turpentine, but this tendency is less than is the case with turpentine. It is inflammable, burning with a luminous and smoky flame with the odour of burning rosin. Its flash point is about 36° to 38° C. (97° to 102° F.).

On heating in a retort, or still, rosin spirit boils and distils over. The temperature at which it begins to boil varies in different samples. The temperature rises during the whole period of distillation, showing that rosin spirit is not a homogeneous compound as is turpentine, but a mixture of various bodies. A sample of rosin spirit examined by the author had the following rate of distillation :—

| | Degrees C. |
|---|---|
| First drop came over at . . . . | 117 |
| 5 per cent. came over below . . . | 127 |
| 8 per cent. more came over below . | 137 |
| 11 ,, ,, ,, . | 149 |
| 3½ ,, ,, ,, . | 159 |
| 18½ ,, ,, ,, . | 168 |
| 2 ,, ,, ,, . | 179 |
| 13 ,, ,, ,, . | 190 |
| 6 ,, ,, ,, . | 200 |
| 8 ,, ,, ,, . | 220 |
| 6 ,, ,, ,, . | 237 |

18·25 per cent. of residue remaining in the flask. Rosin spirit may be met with having lower or higher distilling temperatures.

Low distilling spirit is better than high distilling spirit for paint making.

Rosin spirit is insoluble in water and alcohol, but is soluble in ether, turpentine, chloroform and petroleum spirit or shale naphtha. Nitric acid acts on it rather powerfully, but the action is not so great as with turpentine. Hydrochloric acid has little action. Sulphuric acid forms a dark red mixture.

In composition rosin spirit is a mixture of several hydrocarbon bodies, the exact nature of which has not yet been thoroughly worked out. From it has been isolated heptine, $C_7H_{12}$, a colourless limpid liquid having a specific gravity of 0·8031, and boiling at 103° to 104° C. On exposure to the air it absorbs oxygen. Sulphuric acid polymerises it with the formation of diheptine, $C_{14}H_{24}$, which boils at 235° C. to 250° C., and which, on exposure to the air, rapidly absorbs oxygen and resinifies. When exposed to the air in the presence of water heptine forms crystals of the composition, $C_7H_{10}(OH)_2H_2O$. It combines with bromine to form a dibromide, $C_7H_{10}Br_2$, which is a heavy yellowish oil. In light rosin spirit boiling below 100° C. there have been found hexylene and amylene.

Rosin spirit is the best substitute for turpentine known, as it approaches it in its properties. When of good quality it may be used as a substitute in all cases. The chief objection to it is its strong odour, which is unpleasant to many persons. Care must be taken in refining it so that all traces of rosin oil be extracted, since these would, if present, retard its drying. The specific gravity of a good sample will not exceed 0·880. The whole of such a sample, or nearly all of it, will distil below 250° C.

Rosin spirit is largely employed in making turpentine substitutes, as also for making cheap varnishes, using rosin as the body gum as it is called.

Shale naphtha and petroleum spirit form the only possible adulterants of rosin spirit. These may be detected by their effect on the specific gravity and boiling points.

**ROUGE** is the name given to the residue of ferric oxide left on heating ferrous sulphate in iron retorts. It has a bright red colour, a fine texture and a soft feel. It possesses strong colouring powers and excellent body. It is much used as a pigment, and is prepared of several shades of red and sold under a variety of names, such as scarlet red, Turkey red, etc. It is used for polishing metals, etc. Rouge is completely soluble in hydrochloric acid, yielding a yellow solution containing ferric chloride. There should be no effervescence, and the solution should give no precipitate with barium chloride. On adding ammonia a brown red precipitate of ferric hydroxide is thrown down. On filtering this off and adding to the filtrate ammonium sulphide and ammonium carbonate in succession, no further precipitates should be obtained. The characteristic tests for iron will be found described under *Iron Oxides*.

**ROYAL REDS.**—A group of bright red pigments varying somewhat in tint, which owe their colour to the coal tar colouring matter, eosine. They are prepared by precipitating this dye with lead acetate on to a base of orange lead or a mixture of orange lead and barytes or some other bases. They may be distinguished by the fact that on treatment with alcohol or methylated spirit they colour the alcohol a bright scarlet with fluorescence. On being heated the colour is destroyed. As pigments they possess strong colouring powers, are usually of good body and covering power. Much, however, of their properties in this respect depends upon the nature of the base on which they are made. They work well in oil, the lead they contain usually imparting to them good drying properties. Unfortunately they are fugitive to light. Much, however, depends on the care with which they are made and the vehicle with which they are used in painting. Unless sufficient precipitant has been employed then they are liable to contain free eosine, which increases their fugitiveness. Reds prepared with lead salts are more permanent than those prepared with alumina salts. Used as oil paints they are much more permanent than when used as water colours. See also *Vermilionettes.*

**ROYAL YELLOW.**—A name given to arsenic yellow or king's yellow. See *Arsenic Yellow, King's Yellow.*

**RUBEN'S BROWN.**—Nothing is known as to the nature or origin of the pigment known by this name. It was probably a natural earth resembling umber in its properties and composition.

## S.

**SALT.**—This valuable commodity is a compound of the two elements, sodium and chlorine, in the proportion of 39·32 per cent. of sodium to 60·68 per cent. of chlorine. Its chemical formula is $NaCl$, and its chemical name sodium chloride.

It is found very widely distributed in nature. In many places it is found in large solid masses of a crystalline character. Such deposits occur at Northwich, Middlewich, Droitwich, Middlesborough and other localities in this country. In other parts of the world it occurs in great abundance in the solid form. In solution it is present in small proportion in all natural waters, while the springs which are met with in salt districts are, as a rule, highly charged with it. Sea water is a great source of salt, containing it in large proportion. In some inland seas (Dead Sea, Salt Lake of Utah) the water is practically saturated with salt.

Salt crystallises in cubical crystals of a glistening white colour. It is soluble in about three or four times its weight of cold water, the solubility being but slightly increased on heating. At a temperature of about 700° C. it melts and is volatile at higher temperatures, a property which is taken advantage of in glazing pottery, the salt being thrown into the furnace during the last stages of the burning of the pottery. It is volatilised by the heat of the furnace, and on coming in contact with the articles enters into combination with the silica, forming silicate of soda (to which the glaze is due) while chlorine or hydrochloric acid is evolved.

Salt forms the basis from which all other sodium compounds are obtained. Its conversion into sodium carbonate constitutes the alkali manufacture, one of the most important branches of chemical manufacture. It is employed in dyeing, for food and for numerous other purposes.

**SANDARAC.**—This is a very useful varnish resin which exudes from the alerce tree, *Callitris quadrivalvis*, a native of North Africa, growing in abundance in the mountainous regions from the Atlantic coast to Eastern Algeria. The resin exudes naturally from the tree. The Moors who collect it increase the amount by making incisions in the tree. After collection it is usually sent to Mogador for export to Europe.

Sandarac occurs in small cylindrical pieces or tears (which may be agglutinated together) of a yellowish-white colour. It is hard and brittle, being comparable to rosin or kauri in this respect. It melts at about 150° C. (300° F.) to a colourless or slightly yellow liquid. Its specific gravity is 1·038 to 1·044.

Sandarac is soluble in alcohol, methylated spirit, ether and amyl alcohol. It is only slightly soluble in benzol, petroleum spirit, and turpentine in its natural condition. Sandarac which has been fused, as in the common method of making oil varnishes, becomes soluble in those solvents and in oil.

Sandarac (also known as gum juniper) is much used in making both oil and spirit varnishes when a pale or colourless varnish is required. It forms a very bright varnish and gives a coat which is hard, lustrous and durable.

**SAP GREEN** is a pigment of a dull shade of olive green, formerly prepared in large quantities from the juice of the buckthorn berries by treatment with alum and soda. It is now almost, if not quite, obsolete. In its general composition it is essentially a lake. Its chief use of late has been for the colouring of confectionery and other food products. When used as a pigment it works well in water but not in oil. It is, however, fugitive to light.

**SATIN WHITE.**—A white pigment much used in filling papers and paper staining in general. It is a mixture of calcium sulphate and alumina, and is made by boiling a solution of alum or alumina sulphate with lime water. It possesses good properties as a pigment, has a fair amount of body and covering power, and, what is of service to the paper stainer, it enables the paper to take a high polish when it is calendered.

Satin white may be distinguished by the following tests: On heating with dilute hydrochloric acid the alumina dissolves leaving the calcium sulphate behind. On adding ammonia to the acid solution a white gelatinous precipitate of alumina hydroxide will be obtained. By long boiling with hydrochloric acid satin white is completely dissolved. On adding to the solution, first ammonia and then ammonium oxalate, a copious white precipitate of calcium oxalate will be obtained. Or if barium chloride be added to the solution a white precipitate of barium sulphate will result. An analysis of satin white is rarely required; it is usually sufficient to examine it for its purity of colour and colouring power.

**SCARLET RED.**—A name given to very bright scarlet shades of iron oxide pigments. These may be distinguished from any other pigments similarly named by their giving the characteristic tests for iron. It may be here pointed out that many of the modern pigments prepared from coal-tar colours are sent out under old names. It is of course impossible to state definitely the composition of such pigments. That a particular sample contains or is made from a coal-tar colour can be ascertained by treating a little with alcohol, when, as a rule, it will form a coloured solution.

**SCHEELE'S GREEN.**—An arsenite of copper prepared by precipitating a solution of sulphate of copper with one of arsenite of soda. It has a dull yellow-green colour, possesses a fair body and covering power, but is somewhat deficient in colouring power. It has now become quite obsolete as a pigment. It may be distinguished by the following tests: Boiled with hydrochloric acid it dissolves, forming a green or bluish solution. On adding caustic soda and boiling a black precipitate of copper oxide is obtained. If to the solution a little acid be added and a current of sulphuretted hydrogen gas passed through, a yellow precipitate of arsenic sulphide will be obtained.

**SCHWEINFURTH GREEN.**—A name formerly given to emerald green. See *Emerald Green.*

**SCOFFERN'S WHITE.**—A pigment containing sulphite of lead, but which never came into extensive use.

**SCOTCH FIR SEED OIL.**—An oil obtained by pressure from the seeds of the Scotch fir, *Pinus sylvestris*. It has a brownish-yellow colour, a specific gravity at 60° F. of 0·931, and a somewhat turpentinous odour. It dries well, but is not quite equal to linseed oil in this respect. If it were more abundant it might be used as a paint oil.

**SEED LAC.**—The name given to the partly refined lac obtained by boiling the crude lac with water to extract the colouring matter. Seed lac is by further treatment converted into shellac. See *Lac*.

**SEPIA.**—The name given to the brown pigment which is obtained from the ink bags of the cuttle fish, *Sepia officinalis*. Sepia is mostly used by artists, and is prized by them most particularly for water-colour painting on account of the fine tones it gives and the ease with which large washes of colour can be obtained. Sepia is a compound of calcium and magnesium carbonates with an organic colouring principle. Prout gives its composition as :—

| | Per Cent. |
|---|---|
| Melanin or black pigment . . . | 78·00 |
| Calcium carbonate, $CaCO_3$ . . | 10·40 |
| Magnesium carbonate, $MgCO_3$ . . | 7·00 |
| Alkaline sulphates and chloride . . | 2·16 |
| Organic mucus . . . . . | 0·84 |

Sepia is sometimes sold in its original condition, in which case it takes the form of pears coated with the tissue of the ink bag, or it is often sold in a prepared form. The crude sepia is boiled with a little sodium carbonate, which dissolves out the actual colouring matter; then by adding a little acid to the solution this is reprecipitated, and, after filtering and washing is ready for sale.

**SHALE NAPHTHA or SHALE SPIRIT** is the lightest liquid product obtained in the refining of the crude oil obtained by distilling Scotch shale. The naphtha is a water-white, very limpid liquid, possessing a slight odour and fluorescence. Its specific gravity varies from 0·730 to 0·760. It is very inflammable, taking fire immediately on a light being put to it and burning with a luminous flame. It begins to boil below 100° C. (212° F.), and is usually completely distilled over below 190° C. (374° F.). The temperature of distillation and its range varies with different makes. A sample of Scotch naphtha which had a specific gravity of 0·760 examined by the author had the following range of distillation:—

| | Degrees C. |
|---|---|
| First drop came off at . . . . | 71 |
| 3 per cent. came over below . . . | 90 |
| 10 " " " . . . | 120 |
| 23 " " " . . . | 143 |
| 43 " " " . . . | 150 |
| 60 " " " . . . | 160 |
| 70 " " " . . . | 170 |
| 81 " " " . . . | 180 |
| 90 " " " . . . | 190 |

A naphtha of 0·730 gravity will distil at lower temperatures than will a naphtha of 0·760 gravity.

Acids and alkaline liquids have no action on shale spirit. It will absorb and combine with a small but variable quantity of bromine or of iodine.

Shale naphtha is a complex mixture of hydrocarbons belonging to the two series of paraffins and olefines, the latter forming about 60 per cent. of the naphtha. There have been obtained from it the following among other hydrocarbons: Hexene, $C_6H_{14}$; heptene, $C_7H_{14}$; octene, $C_8H_{16}$; nonene, $C_9H_{18}$, among the olefines; while the following paraffins have been found: Hexane, $C_6H_{14}$; heptane, $C_7H_{16}$; octane, $C_8H_{18}$; and nonane, $C_9H_{20}$. Others are present, but they have not been definitely isolated.

Shale naphtha is largely employed as a solvent or thinner in the preparation of paints and varnishes, as it is a very powerful solvent of oils and of some resins. It is distinguished from both rosin spirit and turpentine by its lower specific gravity and flash point. It is distinguished from turpentine by its low boiling point and the continued rise of temperature during boiling, while it cannot be distilled in a current of steam as can turpentine.

Shale naphtha closely resembles benzoline in its chemical composition and properties, but differs in containing a larger proportion of the olefine hydrocarbons. See *Benzoline*.

**SHELLAC.**—A most valuable varnish resin obtained from lac. See *Lac*.

**SICCATIVES.**—A name often given to driers (see *Driers*). This term is the one usually adopted on the continent, while in England they are more frequently known as driers. Under *Driers* a list of those commonly used is given. The properties of these will be found described under the name for each.

**SIENNA.**—The name given to a class of earthy pigments of a brownish-yellow colour. The original pigment was found near the town of Sienna in Italy, from which circumstance their name is derived. Similar pigments are found in many localities. The best qualities come from the neighbourhood of Rome, but deposits are found in Devonshire, Cumberland, America and other places. Siennas resemble ochres in their general composition, being earthy substances coloured by hydrated oxide of iron. There is usually a little oxide of manganese present, to which circumstance their brownish shade is often but not always due. They differ from ochres in being rather more transparent, a fact which, while rendering them unfit to be used as body colours in a paint, makes them serviceable as staining colours.

The following are some analyses of siennas made by the author:—

*Dark Roman Sienna*:—

| | Per Cent. |
|---|---|
| Water, hygroscopic | 17·55 |
| Water, combined, and organic matter | 9·00 |
| Silica, $SiO_2$ | 22·65 |
| Calcium carbonate, $CaCO_3$ | 0·96 |
| Alumina, $Al_2O_3$ | 2·84 |
| Ferric oxide, $Fe_2O_3$ | 45·82 |
| Manganese, $MnO_2$ | 1·19 |

*Light Roman Sienna*:—

| | Per Cent. |
|---|---|
| Water, hygroscopic | 8·25 |
| Water, combined, and organic matter | 11·00 |
| Silica, $SiO_2$ | 17·41 |
| Alumina, $Al_2O_3$ | 1·07 |
| Manganese, $MnO_2$ | 0·63 |
| Ferric oxide, $Fe_2O_3$ | 57·03 |

*Pennsylvania Sienna*:—

| | Per Cent. |
|---|---|
| Water, hygroscopic | 8·00 |
| Oxide of iron, $Fe_2O_3$ | 62·12 |
| Alumina, $Al_2O_3$ | 14·80 |
| Silica, $SiO_2$ | 14·23 |
| Manganese, $MnO_2$ | 0·36 |
| Calcium oxide, CaO | traces |

*American Sienna:—*

| | Per Cent. |
|---|---|
| Ferric oxide, $Fe_2O_3$ | 74·81 |
| Alumina, $Al_2O_3$ | 5·23 |
| Manganese, $MnO_2$ | trace |
| Calcium oxide, CaO | trace |
| Silica, $SiO_2$ | 6·76 |
| Water, hygroscopic | 7·00 |
| Water, combined | 6·20 |

These analyses of American siennas show that they differ markedly from the Italian siennas. They contain the iron in two forms, hydrated and anhydrous, to which fact they owe their reddish-brown tint. As pigments they are rather more opaque, and, therefore, have more body than Italian siennas.

Siennas are sold in two varieties, known as *raw sienna* and *burnt sienna*. The former is the pigment as obtained; the latter after it has been calcined or burnt in a furnace.

Burnt sienna has a bright orange-red colour. It has a composition similar to that of the raw siennas, but contains less water, and the iron is in the anhydrous condition.

Siennas, whether raw or burnt, are very useful pigments. They mix well with either oil or water, and are perfectly permanent when used as paints exposed to light and air. They mix well with all other pigments.

Siennas should be examined for tint or shade, colouring power, covering power and body by the usual methods. It is rarely that a chemical analysis will be required. If so this can be done on the lines laid down under ochres. See *Ochres*.

**SILICA.**—The oxide of the element silicon is commonly known by the name of silica. Its composition corresponds to the formula, $SiO_2$. It occurs naturally in great abundance and in a great variety of forms. In a crystallised condition it forms the mineral, rock crystal, and occurs in the form of six-sided prisms with a hexagonal pyramid on one or both ends. In a crystalline condition it forms the mineral quartz, which is found in large quantities in various rocks, granite, syenite, etc. In an amorphous condition it occurs as the minerals, flint, chert, etc. In addition, silica is found in combination with various metallic oxides, such as alumina, iron, magnesia, lime, soda, potash, etc.; in a vast variety of minerals, including felspars, micas, steatite, etc. The most important property of silica is its indestructibility. There is only one acid which will attack it, hydrofluoric acid. Alkalies will not attack it in the cold, but if heated with them it enters into combination, silicates being formed. Silica in all its natural forms is exceedingly hard, ranking next to the diamond in this respect. It is quite infusible and will resist the most intense heat, a property which is largely taken advantage of in the construction of furnaces for chemical and metallurgical processes, bricks made of silica being extensively used in building them.

The uses of silica are varied. It enters into the preparation of ultramarine, cobalt blue, smalts, etc., and is employed in making all kinds of pottery and stoneware, in glass making, etc.

There is one form of silica that is of interest, kieselguhr, from the fact that it is due to the agency of low forms of life. This variety has already been described. See *Kieselguhr.*

When an acid is added to a solution of an alkaline silicate or a soluble silicate is treated with hydrochloric acid, the silica separates out in two forms, first as a white gelatinous mass of insoluble hydrated silica, the exact composition of which depends upon the condition under which it is prepared; while there is often left in solution a peculiar variety of hydrated silica known as soluble silica. Both varieties when strongly heated lose their water of hydration and form the anhydrous insoluble silica. Reference may be made to *China Clay*, *Clay*, *Kaolin*, *Felspar*, *Mica*, etc.

**SILICATE OF POTASH.**—When silica is fused with either caustic potash or caustic soda or even the carbonates of the alkalies, and the fused mass allowed to cool, there is formed a glassy mass which is soluble in water. These are known as *soluble glass* or *water glass*, and meet with many applications in the chemical industries. Silicate of potash is obtained when silica and caustic potash are melted together. Commercially it comes into trade in two forms : one a transparent glassy mass, the other a viscid liquid having a specific gravity of 1·38 (76° Tw.). This usually contains 13·43 per cent. of potash, $K_2O$ ; 24·4 per cent. of silica, $SiO_2$ ; and 62·17 per cent. of water. The silicate in this solution has the formula, $K_2O3SiO_2$. The solid silicate contains 30·78 per cent. of potash, $K_2O$, and 68·73 per cent. of silica, $SiO_2$; a composition corresponding to the formula, $K_2O4SiO_2$. Both these forms are known commercially as *neutral*. If silicates are made with a larger proportion of alkali they are then known as *alkaline* silicates. The properties of silicate of potash are identical with those of silicate of soda. See *Silicate of Soda*.

**SILICATE OF SODA.**—This is by far the most important of the soluble silicates. It is made in several forms. One is a solid of glassy appearance, and is what is commonly sold under the name of *soluble glass* or *water glass*. It usually has the composition : Soda, $Na_2O$, 32·13 per cent. ; silica, $SiO_2$, 67·87 per cent. This corresponds to the formula, $Na_2O2SiO_2$. It is slowly soluble in water, yielding very thick viscid solutions. These are decomposed by acids, gelatinous silica being deposited.

An "alkaline" solution of silicate is made having a specific gravity of 1·5 to 1·546 (100° to 109° Tw.). The composition of this solution averages 15·9 per cent. of soda, $Na_2O$; 29·3 per cent. of silica, $SiO_2$; and 54·8 per cent. of water. The silicate in this solution has the formula, $Na_2O2SiO_2$, so that, although termed an alkaline solution, it really is acid in character. The equivalent proportions of soda and silica to form a normal silicate are 1 to 1, $Na_2O$ to $SiO_2$. Sometimes a neutral silicate containing less soda than an alkaline silicate is made, but it is found that for most of the purposes for which silicate of soda is used it is best to keep the proportion of soda to silica as 1 to 2, as in the formula given above. The more silica there is the less soluble becomes the silicate.

When acids are added to solutions of the alkaline silicates the latter are decomposed; the silica separates out, partly in the gelatinous form and partly in solution. On evaporating the acidified solution to dryness the silica is obtained as an insoluble gritty white powder. When mixed with solutions of the heavy metals precipitates are obtained of the respective metallic silicates. When mixed with white lead the mixture quickly sets into a hard enamel-like mass. A mixture of lime and silicate of soda also soon sets into a hard mass. Silicate of soda is much used as a petrifying substance for preserving stone from the destructive influence of the atmosphere. Alternate coatings of lime and silicate form one of the best preservatives known.

**SMALTS.**—This pigment is a glass coloured by oxide of cobalt which has been finely powdered. It is prepared by melting together in a crucible silica, potash and oxide of cobalt, the proportions used depending on the depth of shade required. Smalts used to be very largely employed by bleachers and others, but the introduction of artificial ultramarine has almost completely displaced it.

Smalts is a pigment of a violet blue shade of no great depth of colour. In gaslight the tone changes to a reddish blue. The tint of smalts varies a little, which variation is brought about by using various proportions of the ingredients in the process of manufacture, in order to render them better adapted for use for different purposes. The degree of fineness of the powder of smalts also varies, this being done by attention to the grinding ; generally the finer the smalts the paler it is. It mixes well with either oil or water, but it cannot be considered a good pigment for painting, although it is quite permanent when exposed to light and air.

Smalts is sold in a variety of shades and tints, which the makers distinguish by marks having no special signification and varying with different makers.

In composition smalts is essentially a glass, a double silicate of potash and cobalt with a few minor impurities. Rivot gives the following analysis of a sample of smalt :—

| | Per Cent. |
|---|---|
| Silica, $SiO_2$ | 56·4 |
| Alumina, $Al_2O_3$ | 3·5 |
| Ferric oxide, $Fe_2O_3$ | 4·1 |
| Cobalt oxide, $CoO$ | 16·0 |
| Calcium oxide, $CaO$ | 1·6 |
| Potassium oxide, $K_2O$ | 13·2 |
| Lead oxide, $PbO$ | 4·7 |

But the composition will vary very much, more especially as regards the proportion of the impurities.

Smalts is not readily acted upon by acids and alkalies. This distinguishes it from all other blue pigments. Long digestion with strong hydrochloric acid decomposes smalts, forming a solution of the chlorides of the metals it contains and leaving a residue of gelatinous silica.

A sample of smalts may be examined for its tint, colouring power and fineness of powder. An analysis is rarely required and would be rather difficult to make. The only possible adulterants which might be added to smalts would be ultramarine, Prussian blue and possibly barytes. The first may be detected by the action of dilute acids, the second by the action of alkalies, and the barytes by being left as an insoluble white residue on treatment with hydrochloric acid.

**SOLUBLE BLUE.**—Two different products are known under this name. One is a coal-tar colouring matter, used solely in dyeing and printing textile fabrics; the other a modification of Prussian blue, which is soluble in water. Soluble blue prepared from Prussian blue may be distinguished from the coal-tar product by being decomposed by caustic soda with the formation of a brown insoluble residue of oxide of iron.

**SODIUM CARBONATE.**—This important alkali is manufactured in large quantities from salt, sodium chloride, $NaCl$. There are two chief methods of production known respectively as the Leblanc process and the ammonia-soda process. The *Leblanc process* is the oldest, and was the invention of Nicholas Leblanc, a Paris pharmacist, at the end of last century. In this process the salt is taken and heated with sulphuric acid, whereby it is converted into sodium sulphate or, as it is called, *salt cake*. This is next mixed with limestone and coal and again heated in a furnace when there is produced a product known as *black ash*. This has a most complex composition. The principal constituents are sodium carbonate and calcium persulphide. The black ash is then lixiviated with water, whereby the sodium carbonate is dissolved out and the calcium compound left behind as an insoluble substance known as *vat waste*. The solution of sodium carbonate is then boiled down to dryness and heated in a furnace, when there is formed what is known as *soda ash*. From this the various other forms of sodium carbonate are obtained.

The *ammonia soda process* has been known in principle for a very long time, but no practical method of working it on a large scale was known until Solvay devised his mode of working. In the ammonia-soda process the salt is employed in the form of brine. It is mixed with ammonia and a current of carbonic acid gas is sent in when there is obtained a precipitate of bicarbonate of soda. This is separated and heated in a furnace when it gives off carbonic acid and passes into carbonate of soda. A very pure alkali can be made by this process.

Sodium carbonate (or soda as it is frequently called) is a combination of carbonic acid gas, $CO_2$, and the oxide of the metal sodium, $Na_2O$. There are two carbonates of soda. The one known as the normal carbonate, has the composition shown by the formula, $Na_2CO_3$; the other is the acid carbonate (or, as it is most commonly called, bicarbonate of soda), and has the formula, $NaHCO_3$. Commercial carbonate of soda is sold in a variety of forms.

(1) Soda ash
(2) Refined alkali
(3) Soda crystals
(4) Crystal carbonate
(5) Sesquicarbonate
(6) Bicarbonate

1. *Soda Ash.*—This is the crude carbonate as obtained from the boiling down pans or the furnaces. It is by no means a pure form, but contains a large number of impurities which vary in amount. Caustic soda, sodium chloride, sodium sulphate, sodium sulphite, oxide of iron or alumina may be present. It is made in various qualities, which are distinguished as 48 per cent. ash, 52 per cent. ash, etc., these

percentages showing the amount of sodium oxide, $Na_2O$, present in the sample. Forty-eight per cent. sodium oxide corresponds with 82 per cent. sodium carbonate, while 58 per cent. sodium oxide corresponds with 97 per cent. sodium carbonate. Soda ash is usually sold according to its content of sodium oxide, each per cent. being called a degree and the price quoted (about 1d.) per degree per cwt. Thus a 50 per cent. ash at 1d. per degree would cost 4s. 2d. per cwt. Soda ash is used in a great variety of industries, paper making, bleaching, dyeing, glass making, etc.

2. *Refined Alkali.*—This product is almost pure carbonate of soda and is chiefly made by the ammonia-soda process, and is what is commonly referred to when *Solvay soda* is spoken of. It is usually sent out as containing 58 to 59 per cent. of sodium oxide. It is a fine white powder, easily and completely soluble in water. It is used wherever a pure form is required and where the impurities present in soda ash would have some influence on the result.

3. *Soda Crystals.*—This form is the common washing soda or Scotch soda of the laundress. It is made in fine large crystals, which contain 10 molecules of water of crystallisation. Its formula, therefore, is $Na_2CO_3, 10H_2O$. The use of soda crystals has somewhat declined since the introduction of refined alkali and crystal carbonate.

4. *Crystal Carbonate.*—This is also known as crystal soda. It is a monohydrated crystalline form of sodium carbonate, having the formula, $Na_2CO_3H_2O$, and occurring in very small fine crystals that effloresce on exposure to air. Generally this form is very pure and readily soluble in water. It is, therefore, preferable to soda crystals, than which it is much stronger or about two and a half times as strong.

5. *Sesquicarbonate.*—A form of sodium carbonate, which is a crystalline combination of the normal and acid carbonates,

having the formula, $Na_2CO_3$, $NaHCO_3$, $2H_2O$, has been made but has not come into much use.

6. *Bicarbonate.*—This form has a composition corresponding to the formula, $NaHCO_3$. It is prepared in both crystals and powder, and is the variety commonly used for medicinal and many domestic purposes.

The following are some analyses of the various varieties of commercial carbonate of soda, which will show their relative degree of purity :—

| | 48 per Cent. Ash. Per Cent. | 58 per Cent. Ash. Per Cent. | Ammonia Alkali. Per Cent. | Soda Crystals. Per Cent. | Crystal Carbonate. Per Cent. | Sesquicarbonate. Per Cent. |
|---|---|---|---|---|---|---|
| Sodium carbonate, $Na_2CO_3$ | 60·64 | 98·72 | 98·94 | 34·22 | 81·92 | 46·62 |
| Sodium bicarbonate, $NaHCO_3$ | — | — | — | — | — | 37·30 |
| Sodium sulphate, $Na_2SO_4$ | 4·35 | 0·20 | 0·20 | 2·54 | 0·18 | — |
| Sodium hydroxide, $NaHO$ | 1·29 | — | — | 0·10 | — | — |
| Sodium chloride, $NaCl$ | 28·34 | 0·54 | 0·36 | 0·27 | 0·24 | 0·29 |
| Calcium carbonate, $CaCO_3$ | trace | 0·13 | 0·03 | — | — | — |
| Magnesium carbonate, $MgCO_3$ | trace | 0·04 | — | — | — | — |
| Ferric oxide, $Fe_2O_3$ | trace | 0·04 | trace | trace | — | — |
| Alumina, $Al_2O_3$ | 1·12 | 0·01 | — | — | — | — |
| Silica, $SiO_2$ | — | 0·09 | 0·09 | 0·03 | — | — |
| Water | 43·60 | 0·26 | 0·38 | 62·84 | 17·66 | 15·79 |

Sodium carbonate is fairly easily soluble in water, the solubility increasing with the temperature, but is greatest at 32·5° C. The following table gives the solubility of sodium carbonate at various temperatures :—

| 0° C. | 5° C. | 10° C. | 15° C. | 20° C. | 30° C. | 32·5° C. | 34° C. and 79° C. | 100° C. |
|---|---|---|---|---|---|---|---|---|
| 7·1 | 9·5 | 12·6 | 16·5 | 21·4 | 38·1 | 59 | 46·2 | 45·1 |

parts of $Na_2CO_3$ per 100 water

The following table of the specific gravities of solutio of sodium carbonate at 15° C. (60° F.) will be found useful :

## SPECIFIC GRAVITIES OF SOLUTIONS OF SODIUM CARBONATE AT 15° C. (60° F.).

| Degrees Twaddell. | Percentage by Weight. | | Degrees Twaddell. | Percentage by Weight. | | Degrees Twaddell. | Percentage by Weight. | |
|---|---|---|---|---|---|---|---|---|
| | $Na_2CO_3$. | $Na_2O$. | | $Na_2CO_3$. | $Na_2O$. | | $Na_2CO_3$. | $Na_2O$. |
| 1 | 0·47 | 0·28 | 11 | 5·23 | 3·06 | 21 | 9·90 | 5·79 |
| 2 | 0·95 | 0·56 | 12 | 5·71 | 3·34 | 22 | 10·37 | 6·06 |
| 3 | 1·42 | 0·84 | 13 | 6·17 | 3·61 | 23 | 10·83 | 6·33 |
| 4 | 1·90 | 1·11 | 14 | 6·64 | 3·88 | 24 | 11·30 | 6·61 |
| 5 | 2·38 | 1·39 | 15 | 7·10 | 4·16 | 25 | 11·76 | 6·88 |
| 6 | 2·85 | 1·67 | 16 | 7·57 | 4·42 | 26 | 12·23 | 7·15 |
| 7 | 3·33 | 1·95 | 17 | 8·04 | 4·70 | 27 | 12·70 | 7·42 |
| 8 | 3·80 | 2·22 | 18 | 8·51 | 4·97 | 28 | 13·16 | 7·70 |
| 9 | 4·28 | 2·50 | 19 | 8·97 | 5·24 | 29 | 13·63 | 7·97 |
| 10 | 4·76 | 2·78 | 20 | 9·43 | 5·52 | 30 | 14·09 | 8·24 |

Strong solutions cannot be obtained at the ordinary temperature. At 23° C. water will dissolve about 18 per cent. of sodium carbonate, but on cooling down such solutions deposit crystals.

The testing of soda ash, soda crystals, etc., is done by the usual alkalimetrical tests as described under caustic soda Five grammes of the sample are taken and dissolved in 250 c.c. of water ; 25 c.c. of this solution are taken, and a little methyl orange added ; it is then titrated with normal sulphuric acid until the red acid tint is obtained. The number of c.c. of acid used multiplied by 0·031 gives the weight of sodium oxide, $Na_2O$, or multiplied by 0·053 gives the weight of sodium carbonate, $Na_2CO_3$, in grammes present in the sample. If instead of taking 5 grammes, 3·1 or 5·3 grammes are taken, then the number of c.c. used of the acid multiplied by ten gives the percentage of sodium oxide or sodium carbonate respectively.

**SODIUM BORATE.**—The chemical name of borax. See *Borax.*

**SODIUM CHLORIDE.**—The chemical name of salt. See *Salt.*

**SODIUM HYDROXIDE.**—The chemical name of caustic soda. See *Caustic Soda.*

**SODIUM SULPHATE.**—There are two sulphates of sodium. The most common, and at the same time the most important, is the normal sulphate, which has a composition corresponding to the formula, $Na_2SO_4$. The second one is the acid sodium sulphate, commonly known as bisulphate of soda or sodium hydrogen sulphate. This has the formula, $HNaSO_4$. Both are very largely employed for a great variety of purposes. The normal sulphate is capable of existing in two forms, both of which are manufactured commercially, *viz.*, (1) the anhydrous, corresponding to the formula $Na_2SO_4$, the commercial varieties of which are known as *salt cake* or *nitre cake*, according as they are made by the action of sulphuric acid on salt or on nitrate of soda; and (2) the crystallised sulphate (Glauber's salt), containing 10 molecules of water of crystallisation, and corresponding to the formula, $Na_2SO_4, 10H_2O$, which is made on the large scale from either salt cake or nitre cake by dissolving out and crystallising.

Sodium sulphate is fairly easily soluble in water, which at 0° C. dissolves 5 per cent. of its weight, at 33° C. 50 per cent., and at 100° C. 42·5 per cent. On allowing a solution to slowly crystallise Glauber's salt separates out. The commercial anhydrous varieties are often acid in character, but generally this does not interfere with their use for most purposes. If a neutral compound is required then it is best to drive off the water from Glauber's salt and obtain what is then known as calcined Glauber's salt. Glauber's salt, as usually sold, is fairly good in quality, the most common impurity being sodium chloride.

Sodium sulphate in all its forms is very largely used by colour makers in the preparation of chrome yellows, by dyers, finishers, glass makers, etc. It may be pointed out that so far as regards the use of sodium sulphate for many purposes it is immaterial whether the anhydrous or the crystallised salt be used provided equivalent quantities be taken. Eleven parts of the anhydrous salt are equal to 25 parts of the crystallised salt.

Sodium sulphate should not give any precipitate on the addition of silver nitrate. It should not turn blue litmus paper red, which would indicate acidity. It should not effervesce on the addition of acids, nor give off any gas of any kind.

**SODIUM PHOSPHATE.**—The commercial salt occurs in small crystals not readily soluble in water at the ordinary temperature, which takes up about 1 part in 25. At the boiling point it is readily soluble in its own weight of water. It has a composition corresponding to the formula, $HNa_2PO_4$, $12H_2O$, containing:—

| | Per Cent. |
|---|---|
| Sodium oxide, $Na_2O$ . . . . | 17·32 |
| Phosphoric pentoxide, $P_2O_5$ . . | 19·84 |
| Water of crystallisation . . . | 62·84 |

It is efflorescent on exposure to the air.

Sodium phosphate is used in many industries, such as dyeing, calico printing, colour making, etc. The commercial salt is fairly pure, the most common adulterant being sodium sulphate. A good sample of sodium phosphate should not give a precipitate with barium chloride from a solution acidified with hydrochloric acid, and it should not give a precipitate with silver nitrate in a solution acidified with nitric acid. On adding a little nitric acid to a solution of sodium phosphate, then a little ammonium molybdate, and boiling, a bright yellow precipitate of ammonium phosphomolybdate will fall down. This test is very characteristic of phosphoric acid.

**SPANISH WHITE.**—The name given to a good quality of whiting. Originally it was probably given to a white clay imported from Spain.

**STRONTIUM WHITE.**—This pigment is the sulphate of strontium, which occurs naturally as the mineral celestine. It has a composition shown by the formula, $SrSO_4$, and is analogous to barytes and gypsum. Strontium white occurs only in small quantities ; consequently it is not much used. In its general properties it closely resembles barytes. It is insoluble in water, acids and other solvents. It can be distinguished from barytes by its giving a red colour to the Bunsen flame.

**SUGAR OF LEAD.**—A common name of lead acetate. See *Acetates of Lead.*

**SUBLIMED WHITE LEAD.**—A white pigment prepared by melting lead or lead ores in a furnace and blowing air through. The lead ore, galena, undergoes oxidation and is converted into lead sulphate, a little lead oxide being formed at the same time. The lead sulphate, etc., is carried away by the blast of air in the form of fume, which is collected in suitable condensing chambers. It is next treated with a little sulphuric acid, washed and dried. The original sublimed white lead contained some zinc oxide, owing to a lead ore containing zinc being used in its preparation. It is customary to add a little zinc oxide and barytes to the lead sulphate which is formed in the process. A sample of sublimed white lead examined by the author contained :—

| | Per Cent. |
|---|---|
| Lead sulphate, $PbSO_4$ | 82·39 |
| Lead oxide, $PbO$ | 0·55 |
| Zinc oxide, $ZnO$ | 6·34 |
| Lead carbonate, $PbCO_3$ | 9·42 |
| Hygroscopic water | 0·35 |
| Combined water | 1·05 |

When well made sublimed white lead possesses good colour body and covering power. It works fairly well in oil, but not so well as ordinary white lead. It is permanent when exposed to light and air, and is non-poisonous. These properties give it an advantage over ordinary white lead.

Sublimed white lead may be distinguished from ordinary white lead by the following reactions: It is not soluble in dilute nitric acid, the insoluble portion consisting of lead sulphate with any barytes which may have been added. The soluble portion will consist of the lead oxide, lead carbonate and zinc oxide which may be present. On adding ammonia to this solution a white precipitate of lead hydroxide will be obtained. On filtering this off and adding ammonium sulphide to the filtrate a white precipitate of zinc sulphide will be thrown down. On boiling sublimed white lead with hydrochloric acid it dissolves and the solution gives a white precipitate of barium sulphate on adding a solution of barium chloride. On cooling the solution, it deposits white crystals of lead chloride.

Sublimed white lead should be assayed for colour, body, covering power and colouring power in the usual way, as samples are apt to vary in these particulars from time to time.

**SULPHATES.**—These are an important group of salts derived from a combination of metallic or other bases with sulphuric acid. Monad metals, like sodium, potassium and silver, form sulphates of the type $M_2SO_4$; dyad metals, like barium, lead and calcium, sulphates of the type $MSO_4$; while triad metals, like bismuth and aluminium, form sulphates of the type $M_23SO_4$. There are only four insoluble sulphates, those of lead, $PbSO_4$; barium, $BaSO_4$; strontium, $SrSO_4$; and calcium, $CaSO_4$. The last named is slightly soluble in water (about 1 part in 500). The barium salt is the most insoluble, while the lead sulphate follows it very closely. All other sulphates are more or less soluble in water.

They are very important compounds. Those of lead, barium, strontium and calcium are used as pigments; while others, such as the sodium sulphate, are employed in making pigments.

The characteristic test for sulphates is the production of an insoluble white precipitate of barium sulphate on adding a solution of barium chloride to one of the sulphate acidified with hydrochloric acid.

The sulphates of lead, sodium, strontium, barium and calcium have already been described. Magnesium sulphate is the well known and valuable Epsom salts. It is not used in colour making.

**SULPHUR.**—This element is important on account of the useful compounds it forms with the metals and other elementary bodies. To it is assigned the symbol S. It has an atomic weight of 32. It has a yellow colour, and is a poor conductor of heat, but is combustible, burning to sulphur dioxide. It is capable of combining with all metals, forming a class of compounds known as sulphides. Some of these are used as pigments, *viz.*, mercury sulphide (vermilion), cadmium sulphide (cadmium yellow), antimony sulphide (antimony orange), arsenic sulphide (king's yellow), and zinc sulphide (zinc white). Combined with oxygen it forms two oxides, the dioxide, $SO_2$, and the trioxide, $SO_3$, both of which are acid oxides capable of combining with basic oxides, the first, to form sulphites; the last, to form sulphates. See *Antimony Orange*, *Cadmium Yellow*, *King's Yellow*, *Vermilion*, *Zinc White*.

**SULPHURIC ACID.**—Probably the most important acid known. It is manufactured on a very large scale, and is applied in a great number of the chemical and allied industries, dyeing, calico printing, colour making, etc. It is a compound of sulphur, hydrogen and oxygen, in the proportions represented by the formula, $H_2SO_4$. It is manufactured by passing the vapours of sulphur dioxide, nitric acid and steam into large leaden chambers where a reaction takes place and sulphuric acid is formed in the state of solution. This weak acid is then concentrated by evaporation until it reaches a specific gravity of 1·846 (169° Tw.), and containing about 98 per cent. of actual sulphuric acid.

Sulphuric acid or, as it was commonly known, *oil of vitriol*, is a heavy oily liquid of 1·84 to 1·86 specific gravity. It mixes with water in all proportions, the mixture giving rise to the evolution of much heat; hence in mixing these two liquids great care must be taken or accidents may happen. The acid should be poured into the water, never the water into the acid.

It will be noticed that the specific gravity increases with the proportion of sulphuric acid up to a certain point, that is, when there is 97·7 per cent. of actual acid present, then the gravity is 1·8415; after which it decreases again, and an acid of 99·9 per cent. strength is actually lower in gravity. The same phenomenon is observable in the case of other substances, for example, acetic acid (see p. 6).

The following table shows the specific gravity and strength of solutions of sulphuric acid :—

### TABLE OF SPECIFIC GRAVITIES OF SULPHURIC ACID SOLUTIONS AT 60° F. (15° C.).

| Degrees Twaddell. | Specific Gravity. | Per Cent. of $H_2SO_4$. | One Gallon | |
|---|---|---|---|---|
| | | | Weighs Lb. | Contains Lbs. $H_2SO_4$. |
| 40 | 1·200 | 27·32 | 12 | 3·24 |
| 45 | 1·225 | 30·48 | 12¼ | 3·73 |
| 50 | 1·250 | 33·43 | 12½ | 4·2 |
| 55 | 1·275 | 36·29 | 12¾ | 4·6 |
| 60 | 1·300 | 39·19 | 13 | 5 |
| 65 | 1·325 | 42·08 | 13¼ | 5·5 |
| 70 | 1·350 | 44·82 | 13½ | 6 |
| 75 | 1·375 | 47·47 | 13¾ | 6·4 |
| 80 | 1·400 | 50·11 | 14 | 7 |
| 85 | 1·425 | 52·63 | 14¼ | 7·5 |
| 90 | 1·450 | 55·03 | 14½ | 8 |
| 95 | 1·475 | 57·37 | 14¾ | 8·4 |
| 100 | 1·500 | 59·7 | 15 | 9 |
| 105 | 1·525 | 62·0 | 15¼ | 9·45 |
| 110 | 1·550 | 64·26 | 15½ | 10 |
| 115 | 1·575 | 66·30 | 15¾ | 10·44 |
| 120 | 1·600 | 68·51 | 16 | 11 |
| 125 | 1·625 | 70·74 | 16¼ | 11·85 |
| 130 | 1·650 | 72·87 | 16½ | 12 |
| 135 | 1·675 | 74·97 | 16¾ | 12·5 |
| 140 | 1·700 | 77·17 | 17 | 13·1 |
| 141 | 1·705 | 77·60 | 17 | 13·22 |
| 142 | 1·710 | 78·04 | 17·1 | 13·23 |
| 143 | 1·715 | 78·48 | 17·15 | 13·25 |
| 144 | 1·720 | 78.92 | 17¼ | 13·67 |
| 145 | 1·725 | 79·36 | 17¼ | 13·69 |
| 146 | 1·730 | 79·8 | 17·3 | 13·81 |
| 147 | 1·735 | 80·24 | 17·3 | 13·9 |
| 148 | 1·740 | 80·68 | 17·4 | 14·0 |
| 149 | 1·745 | 81·12 | 17½ | 14·1 |
| 150 | 1·750 | 81·56 | 17½ | 14·27 |
| 151 | 1·755 | 82·00 | 17½ | 14·4 |
| 152 | 1·760 | 82·44 | 17·6 | 14½ |
| 153 | 1·765 | 82·88 | 17·7 | 14·6 |
| 154 | 1·770 | 83·32 | 17¾ | 14¾ |
| 155 | 1·775 | 83·9 | 17¾ | 14·9 |

## TABLE OF SPECIFIC GRAVITIES OF SULPHURIC ACID SOLUTIONS AT 60° F. (15° C.)—(*continued*).

| Degrees Twaddell. | Specific Gravity. | Per Cent. of $H_2SO_4$. | One Gallon. | |
|---|---|---|---|---|
| | | | Weighs Lbs. | Contains Lbs. $H_2SO_4$. |
| 156 | 1·780 | 84·5 | 17·8 | 15 |
| 157 | 1·785 | 85·1 | 17·8 | 15·2 |
| 158 | 1·790 | 85·7 | 18 | 15·3 |
| 159 | 1·795 | 86·3 | 18 | 15·5 |
| 160 | 1·800 | 86·9 | 18 | 15·64 |
| 161 | 1·805 | 87·6 | 18 | 15·81 |
| 162 | 1·810 | 88·3 | 18·1 | 15·98 |
| 163 | 1·815 | 89·05 | 18·1 | 16·21 |
| 164 | 1·820 | 90·05 | 18¼ | 16·4 |
| 165 | 1·825 | 91·00 | 18¼ | 16·6 |
| 166 | 1·830 | 92·1 | 18·3 | 16·9 |
| 167 | 1·835 | 93·43 | 18·35 | 17·2 |
| 168 | 1·840 | 95·6 | 18·4 | 17·6 |
| 168 | 1·8410 | 97·00 | 18·4 | 17·8 |
| 168 | 1·8415 | 97·7 | 18·4 | 18 |
| 168 | 1·8410 | 98·2 | 18·4 | 18 |
| 168 | 1·8400 | 99·2 | 18·4 | 18¼ |
| 168 | 1·839 | 99·7 | 18·4 | 18·34 |
| 168 | 1·8385 | 99·9 | 18·4 | 18·4 |

Sulphuric acid acts upon most metals, the result being the evolution of hydrogen or of sulphur dioxide and the formation of the metallic sulphates. On iron, zinc, copper, mercury and some others, the acid has no action when concentrated and in the cold; but, if heated, sulphur dioxide is given off. Lead is slowly dissolved with evolution of hydrogen. This inaction of strong sulphuric acid on certain metals is taken advantage of in acid works for the storing and transport of the acid from place to place, iron vessels being used for the purpose. Dilute sulphuric acid has a solvent action on iron zinc, magnesium, etc., with the evolution of hydrogen. On lead, copper and a few other metals dilute acid has no action, either cold or hot.

With the exception of the sulphates of barium, strontium, calcium and lead, which are insoluble, the sulphates are soluble in water. Barium sulphate, which occurs naturally as the mineral barytes, is one of the most insoluble substances known. Lead sulphate is soluble in hydrochloric acid. Calcium sulphate is slightly soluble in water and in acids. Strontium sulphate is very insoluble.

The sulphates are very extensively employed in the industrial arts, barium, strontium, calcium and lead sulphates as pigments; sodium sulphate in glass making, etc.; magnesium sulphate in various operations; copperas (ferrous sulphate) in colour making, etc.

The best test for sulphuric acid and sulphates is that it will give a white precipitate of barium sulphate with barium chloride, which is insoluble on boiling with hydrochloric acid.

The strength of a sample of sulphuric acid may be tested either volumetrically or gravimetrically. If the sample of acid be free from any other acid substances then the volumetrical process may be used. Five grammes of the acid are weighed out and dissolved with water to 200 c.c. Twenty c.c. of this solution are taken, a little phenol-phthalein is added, and the solution is titrated with a standard normal solution of caustic soda until a red colour is obtained. The number of c.c. used multiplied by 0·049 gives the weight of acid present. If the sample of acid should contain other acid constituents then the gravimetric process must be used. Two grammes of the acid are weighed out, dissolved in water, and a little hydrochloric acid added to the solution, which is then brought to the boil and sufficient barium chloride added to precipitate all the sulphuric acid as barium sulphate. This precipitate is then filtered off, well washed with water, dried, burnt in a crucible and weighed. The weight of the barium sulphate so obtained multiplied by 0·4206 gives the weight of sulphuric acid present.

Sulphuric acid has a most powerful action on organic substances. In general it acts as a dehydrating agent in virtue of its great affinity for water, resulting in carbon being set free from many organic compounds, especially if their composition be at all complex. This is the case with sugar, starch, tartaric acid, etc. In some cases it takes up the elements of water with the formation of simpler compounds, as is the case with alcohol, oxalic acid, etc. With other bodies, benzene, indigo, naphthol, etc., it forms what are known as sulphonic acids, hydrogen being taken out and replaced by the group, $HSO_3$. Generally these sulphonic acids are soluble in water. This reaction is taken great advantage of in the manufacture of the coal-tar colours. On turpentine sulphuric acid acts as a polymerising agent, converting the turpentine into a compound with a much higher boiling point.

The same phenomenon occurs with the olefine series of paraffin hydrocarbons. On oils sulphuric acid has a charring action, and great heat is evolved, which is greatest in the case of linseed oil. On castor oil and some other oils sulphuric acid exerts a sulphonating action and fatty acid products are obtained which are soluble in water. On this property is based the use of castor oil in making alizarine oil or oleine oil for use in dyeing and calico printing.

Sulphuric acid is the strongest acid known. It will liberate all other acids from their combinations with basylous bodies —this property being used in chemical manufactures for preparing various acids.

**SULPHUROUS ACID.**—When sulphur is burnt in air or oxygen it forms the oxide, sulphur dioxide, $SO_2$. This is soluble in water and there is then formed a solution of sulphurous acid, $H_2SO_3$. The acid itself is unknown, for all attempts to prepare it have failed.

Sulphurous acid and sulphur dioxide have the peculiar pungent odour characteristic of burning sulphur. They exert a bleaching action on organic colouring matters, and hence are largely used for bleaching wool, silk and other textile fibres. With the basic bodies sulphurous acid forms sulphites, many of which have some commercial interest. The acid sulphites, or bisulphites as they are called, are used as antiseptics, as also in bleaching, dyeing and calico printing.

Sulphites are of no particular interest in the colour industry. They are mostly soluble in water, are decomposed by acids with evolution of sulphur dioxide, and when treated with nitric acid or other oxidising agent are converted into sulphates.

## T.

**TERRA ALBA.**—A name frequently given to ground gypsum. See *Gypsum*.

**TERRA VERTE or TERRE VERTE.**—A natural green pigment found in many places. At one time it was greatly used for painting, but of late it has shown a tendency to be neglected for this purpose. Verona green or Verona earth is a similar pigment. The composition of terre verte varies considerably. Berthier gives the following analysis :—

| | Per Cent. |
|---|---|
| Silica, $SiO_2$ | 51·21 |
| Oxide of iron, FeO | 20·72 |
| Soda, $Na_2O$ | 6·21 |
| Alumina, $Al_2O_3$ | 7·25 |
| Magnesia, MgO | 6·16 |
| Water | 4·49 |
| Manganese | trace |

Klaproth gives the following analysis of a sample from Cyprus :—

| | Per Cent. |
|---|---|
| Silica, $SiO_2$ | 51·5 |
| Oxide of iron, FeO | 20·5 |
| Potash, $K_2O$ | 18·0 |
| Magnesia, MgO | 1·5 |
| Water | 8·0 |

The following is an analysis made by the author of a sample of terre verte from Rome :—

| | Per Cent. |
|---|---|
| Hygroscopic water | 1·45 |
| Combined water | 3·65 |
| Oxide of iron, FeO | 26·87 |
| Alumina, $Al_2O_3$ | 3·16 |
| Lime, CaO | 2·06 |
| Silica, $SiO_2$ | 52·12 |
| Magnesia, MgO | 10·66 |

From these analyses terre verte appears to be a double silicate of ferrous oxide and magnesia or other alkaline base. In the last case the pigment consists essentially of the mineral bronzite, a double silicate of magnesia and iron, the latter metal being present in the metallic condition.

Terre verte is a permanent pigment, and may be used with all vehicles. It is, however, deficient in body and strength of colour. Heat turns the colour of terre verte a reddish colour.

**TANNIN BLACKS** are varieties of black pigments prepared by acting on various tannin materials with iron salts. They are very little used.

**TESTING PIGMENTS.**—Pigments may be examined in several ways. One may have regard to their chemical composition. This is of importance in connection with such as white lead, zinc oxide, vermilion, red lead, cadmium yellow, emerald green, which are definite in their composition and are comparatively costly. In cases like ochres, umbers, Brunswick greens, where the chemical composition varies very much, then a chemical examination is of little value.

Pigments owe their value as paint formers to the possession of certain properties in a greater or less intensity. First, they should be *permanent when exposed to light and air*. Some, such as crimson lake, carmine, etc., fade when used as paint. Others, like the ochres, oxide reds, ultramarine, are quite permanent. Then the pigment should possess *opacity*, which gives it what the painter calls *body*, that is, the power of hiding the surface of the object on which the paint is spread. *Colouring power* should be a strong feature of pigments. Another property of value is the *covering power* of pigments, that is, the comparative extent of surface they will cover when mixed with oil, etc., into a paint. Zinc white, for instance, has a greater covering power than white lead. On the other hand, its body is not so good. Painters frequently confuse body and covering power together. They are certainly closely related, but they are distinct. Another feature of pigments should be their *power of mixing with other pigments*. Some, such as ultramarine, cannot be safely mixed with white lead or other pigments containing lead without risk of their becoming black. On the other hand, oxide of iron reds and ochres may be mixed with all other pigments without any fear of ulterior change.

The following directions for testing pigments for the properties enumerated above will be found useful :—

1. **Colour or Hue.**—There are certain terms employed by colourists which are confusing in their applications. These are colour, hue, tint and shade. The two latter are in constant

use. Some persons distinguish between the two, inasmuch as they consider a tint of a colour to be one obtained by mixing the colour with white; and, on the other hand, by shade they mean that modification which is or can be produced by mixing the colour with black. In the great majority of cases the term *tint* is used for denoting those colour effects obtained by using only a small proportion of the colouring matter, and *shade* the effects obtained by using a large proportion of the colouring matter. It is in this sense that the dyer and textile colourist uses the term. The painter may also apply them in a similar way. In this case he will produce his tints by mixing his pigments with a white body colour and his shades by mixing them with black or some other dark colour

By *hue* is meant that optical effect which the colouring matter produces when viewed by the eye. This is important in connection with pigments. Some, such as vermilion or emerald green (which are constant in their chemical composition), do not differ much; but in other cases, chrome yellows, Brunswick greens, ochres, vermilionettes, etc. (where the chemical composition is not a definite one), the hue may vary considerably; and as it is important in decorative work that the tint of a particular work shall be kept uniform throughout, it is necessary that the painter should always use pigments of one uniform tint or hue. Pigments may be examined for this property in a very simple manner. A sheet of white paper is placed on a table in front of a well-lighted window, then a little of the sample to be examined is placed in a small heap on the paper and the top flattened down with a palette knife so that a level surface is exposed. Next there is placed a similar heap of a standard sample (for this feature of pigments can only be observed by comparison) adjoining the first heap, the hue of the two samples compared together, and the direction in which the two differ noted. Thus, of two samples of chrome yellow one may have a greener tint than the other. One sample of ultramarine may be redder in hue than another sample. This is a simple method of making an examination of colour. To obtain satisfactory results the light must be good and the observer must be able to appreciate minute differences in the hue of the colours compared. By this mode of testing the hue of one sample is compared with that of another and standard sample. In considering hue of a pigment two points may be taken into account: first, *depth*; second, the *tone*. One colour or pigment may be as deep in colour, but differ in what is known as tone or hue in the manner indicated above. A difference in depth may show some difference in the colouring power of a pigment, while a difference in tone may, and often does, have an influence on the use of the pigment for various purposes. Thus, for instance, greens are frequently made by mixing chrome yellow and Prussian blue together. A yellow which has an orange tone about it will not make as good a green as one which is greenish in tone.

Another important feature of pigments, *viz.*, the *brilliance* of hue, may be compared at the same time as the main property just dealt with. This is important, for pigments often vary in brilliancy. Some samples of vermilionettes are much brighter than others. The same thing occurs with ochres and many other kinds of pigments.

2. **Colouring Power.**—Colouring power is that property of pigments by which they are enabled to impart colour to various bodies. This power varies very much even in the same kind of pigments. Thus, of two samples of iron red, one may have ten times the power of the other. Some pigments have great colouring powers, Prussian blue for instance. One lb. of this pigment will give a perceptible blue tint to 1

cwt. of white lead. On the other hand, 1 lb. of smalts would have but little influence on the tint of the white lead. Some pigments, Prussian blue, ultramarine, carmine, vermilionettes, are used solely on account of the colouring power they possess.

The colouring power of pigments is tested entirely in a comparative manner, the following method being adopted: Ten grammes of the sample are mixed with 30 grammes of china clay; 10 grammes of a standard sample of the same pigment are also mixed with 30 grammes of china clay; then the tints of the two mixtures are compared in the manner described above. That mixture which has the deepest tint has been made with the sample which has the strongest colouring power. Some idea of the relative strength of colouring power may be obtained in the following manner: To the darkest of the two mixtures 2 grammes of china clay are added and well mixed with it. The tint of the two mixtures may now be compared. If the tint is still the deepest 2 more grammes of china clay are added, mixed and the tint again compared; this operation is repeated until the two mixtures are of the same tint. It may be assumed that the colouring power is proportional to the quantity of china clay used. Thus, if in one case 30 grammes of china clay were used, and in another sample 37·5 grammes, then the ratio of colouring power would be as 30 to 37·5; or, if the colouring power of the strongest sample be taken as 100, then the colouring power may be expressed in percentages. In this case it will be as 37·5 : 30 : : 100 : 80; that is, the weakest colour has only 80 per cent. of the colouring power of the strongest sample.

As a toning colour for ascertaining the colouring power of all pigments except whites china clay may be used with good results. Gypsum also makes a good toning colour.

White lead and barytes are a trifle too heavy. For white pigments animal black makes a good toning colour.

3. **Covering Power.**—The painter often confuses together two properties of pigments, *viz.*, covering power and body. This is in consequence of both these features showing themselves at one time, and the difference not being carefully differentiated by painters and writers on painting and pigments. It is somewhat difficult to define covering power, but by it is meant the spreading power of the pigment when made into paint as indicated by the extent of surface that may be covered by it. If equal weights of various pigments be mixed with raw linseed oil, sufficient being used in each case to convert the pigment into a paint of working consistence, and each paint be spread carefully over a surface in as uniform a manner as possible, then that pigment which gives a paint that can be spread over the greatest surface has the most covering power. The paint should be spread over a square or rectangular surface, so that the extent of surface may be readily measured. As an example of how this method can be worked the following are some figures obtained by the author: Two grammes of white pigment were mixed with raw linseed oil in sufficient quantity to enable them to spread properly. The surface covered was measured, and the following relative figures were obtained:—

| | |
|---|---|
| White lead (Dutch process) . . | 760 |
| White Lead Co.'s white lead . . | 1,120 |
| Gypsum . . . . . . | 1,440 |
| Barytes . . . . . . | 1,144 |
| Orr's patent zinc white . . . | 1,500 |
| Zinc white . . . . . | 1,152 |
| Lead sulphate . . . . . | 640 |
| White lead (Gardner's process) . . | 1,056 |

From which it appears that Orr's white excels others in its covering power, while white lead is among the lowest.

4. **Body.**—This is a most important property of pigments and one which largely governs their use in painting. A pigment may possess good colouring and covering powers, but may be deficient in body. It will, therefore, not be so extensively used as a pigment which may have good body, but be more or less deficient in the other two properties. By *body* is meant the power of hiding the surface on which the paint is spread in which the pigment is used. Painters distinguish between body colours and stainer colours. To the former class of pigments paint owes its consistency, while to the latter it owes its colour. Body is tested in the same way as covering power. The pigment is made into a paint with linseed oil and spread over a piece of glass or, preferably, a black surface. That pigment which, on holding the glass up to the light, obscures it the most, or which most effectually hides the black surface has the most body. The body of pigments cannot well be measured in figures. It is only by comparing both the covering power and body that the true value of pigments can be determined.

5. **Durability or Permanence.**—Durability to exposure to the weather, light, etc., is one of the most important properties a pigment should possess. When a pigment is made into a paint and this is used then the paint is exposed to influences of a destructive character. First, there is the action of light on the colour. Some colours cannot be exposed for any length of time without fading. Of such crimson lake, yellow lake, emerald green, are examples. There are others, however, which resist the destructive action of the light; such are yellow ochre, Indian red, Prussian blue, ultramarine, etc. Others, again, are but slightly affected. Then exposure to the alternations of weather has a destructive action on pigments and paint. It is a well-known fact that paint has a longer life when used on indoor work than it has when used

on outdoor work. The changes of heat and cold cause expansion and contraction which, sooner or later, leads to cracking and other defects. Moisture, again, plays a great part in leading to the destruction of paint, mainly by so destroying the oil that the pigments are no longer held to the surface by an adhesive material and are washed away.

It is by no means easy to test the durability of pigments, as a very long time is required for the purpose. Some experiments made by Messrs. Abney and Russell for the Science and Art Department on this subject took two years.

A good plan is to take a board with a good surface, not too porous, and to divide it into squares. Now take the pigments to be tested and rub them into paint with oil or water as may be most convenient. Cover the squares with the paint and then expose the board to the air and light. At intervals of a week observations may be made as to how the pigments are behaving. Another plan is to make a number of washes of the paint so that a series of graduated tints are obtained. Half of these tints are covered up with a piece of board, while the other half is exposed; then at intervals the tests are examined and the effect of the exposure determined.

The author's *Manual of Painter's Colours* may be referred to for further details of the methods of testing colours here described. See also Jones' *Testing and Valuation of Raw Materials used in Paint and Colour Manufacture.*

**THENARD'S BLUE.**—A synonym of cobalt blue. See *Cobalt Blue.*

**THUS or GUM THUS.**—The name given to the resinous deposit collected from pine trees and employed chiefly for the preparation of turpentine and rosin (see *Rosin*, *Turpentine*). It is used to a small extent in making varnishes. It is a soft resinous mass of a dark cream colour with an odour of turpentine. On exposure to air it becomes hard and brittle from loss of the volatile turpentine it contains.

**TIN OXIDE or STANNIC OXIDE,** having the formula $SnO_2$, is made by treating metallic tin with nitric acid, whereby it is converted into metastannic acid, which is then heated to redness. Thus prepared it is a pale yellowish powder, commonly sold as putty powder. It is employed in polishing glass, making enamels, and for imparting a yellow colour to glass and pottery. It is insoluble in hydrochloric, nitric, and most other acids. Strong sulphuric acid will dissolve it. From this solution water throws down the oxide as a white precipitate. Tin oxide is soluble in alkaline solutions, forming the stannates of the alkalies. Tin oxide occurs naturally as the mineral cassiterite or tin stone.

**TITANIUM GREEN.**—The ferrocyanide of titanium, prepared by mixing solutions of potassium ferrocyanide and titanium chloride together. It is but rarely used, being rather expensive. When first introduced it was employed as a substitute for the arsenical greens.

**TRAGACANTH.**—See *Gum Tragacanth.*

**TURKEY RED.**—A name often given to bright oxide of iron reds of excellent quality. See *Iron Reds*, *Oxide Reds.*

**TURMERIC.**—This substance is a natural yellow dyestuff obtained from the root of several plants of *Curcuma;* the best is obtained from *Curcuma longa.* The other more important species are *Curcuma tinctoria* and *Curcuma rotunda.* The principal portion of the turmeric of commerce comes from Bengal and Madras in India. Some small supplies are also obtained from Siam, China and Singapore.

As imported turmeric occurs in the form of root-shaped masses, usually single, but sometimes branched. They are externally of a greyish colour; internally they have a deep and fairly bright orange-yellow colour. In taste they are bitter and hot; the odour is pungent and characteristic. Turmeric root contains 11 to 12 per cent. of a yellow colouring matter, 10 to 11 per cent. of a brown resin, 1 per cent. of volatile oil, 14 per cent. of gummy matter, 57 per cent. of starch, soluble salts, etc., and about 7 per cent. of water. Turmeric is also sold in the form of a yellow powder, being the root ground up.

Turmeric contains a yellow colouring matter, known as *curcumin*, a body to which the formula $C_{14}H_{14}O_4$ is given. It is but slightly soluble in cold, more freely in hot water. It can be extracted from the turmeric by treating with hot water, evaporating the solution to dryness, then extracting with benzene and purifying by crystallisation from alcohol. Curcumin forms needle-shaped crystals of an orange-red colour with a blue reflection. It is odourless and melts at 178° C. It is slightly soluble in water, and freely soluble in alcohol, methyl alcohol and glacial acetic acid. It is insoluble in petroleum ether. In strong sulphuric acid curcumin dissolves with a purple colour, changing to black owing to charring. In alkalies it dissolves with a brown-red colour. Curcumin and turmeric are very sensitive to alkalies; hence turmeric solution, or paper dipped in it, is employed for the purpose of detecting alkalinity in liquids.

A characteristic reaction of curcumin is that in the presence of acid it gives a brown colour with boric acid. This reaction is employed to detect the presence of borax in any substance.

Turmeric root is rarely adulterated, but turmeric powder is sometimes mixed with starch and mineral matters. The latter can be detected by the increase in the proportion of mineral matter present. In good turmeric this rarely exceeds 5 per cent., and is often less. It consists chiefly of soluble alkaline salts. An analysis of any mineral matter left on burning a sample of turmeric will show if mineral matter has been added. Starch can be best detected by the microscope. Its addition also reduces the proportion of mineral matter and increases the soluble matter present in the sample.

Turmeric is employed to give a yellow colour to varnishes and staining fluids, such yellow colour being fairly permanent. It is also employed in dyeing, but its use in this industry is becoming obsolete, yellow dyestuffs from coal tar taking its place. It is of interest to note that turmeric is capable of dyeing cotton without a mordant, being one of the few natural colouring matters capable of doing so.

**TURNBULL'S BLUE.**—The blue pigment obtained by adding a solution of potassium ferricyanide to one of ferrous sulphate. It is essentially a ferricyanide of iron. The name Turnbull's blue is not used commercially, this blue being sold under the name of Prussian blue. Its properties are identical with the last-named pigment. See *Prussian Blue.*

**TURNER'S YELLOW.**—See *Patent Yellow.*

**TURPENTINE** is the term originally applied to certain resinous exudations from trees, chiefly from coniferous trees like the pine and fir. Several kinds of turpentine were at one time specially distinguished, such as Venice turpentine, Chian turpentine, etc., but practically all these have gone out of use, or rather the real things are now difficult to obtain, and what are sold under these names are often artificial productions. The term turpentine is now applied almost solely to the liquid spirit which is obtained when the crude resin from pine trees is subjected to distillation with steam. In early days it was known as *spirit of turpentine* on account of its volatile character. It is commonly known now to painters as *turps*.

There comes into the market three varieties of turpentine, American, Russian and French. The first is the principal variety. A fair quantity of the Russian turpentine is sold; but of French turpentine but little finds its way into the English market—the bulk of what is produced being used in France.

The crude resin is collected at certain periods of the year from the pine trees; in America chiefly from the Georgia pine (*Pinus australis*) and the loblolly pine (*Pinus tæda*). French turpentine is chiefly obtained from the maritime pine (*Pinus maritima*); while Russian turpentine is obtained from the Scotch fir (*Pinus silvestris*). The process of extraction of the turpentine from the crude resin is, with some minor differences in the construction of the apparatus, the same in all the countries. The crude material is placed in a still and melted by fire. There is then sent into the still a current of steam which causes the turpentine to distil over, the volatile portions being sent through a condenser where the steam and spirit are condensed and flow into a receiver. The turpentine being the lightest collects at the top of the water and is taken off from time to time, the water being used over again. There is left behind in the still a liquid residue, which, on being run out, solidifies and then forms the product known in England and America as rosin (see *Rosin*) and in France as colophony. All the different varieties of turpentine closely resemble one another.

Turpentine is a hydrocarbon compound having the chemical formula, $C_{10}H_{16}$. There are, however, a number of isomeric bodies which are similar in composition and in properties. These have been named the *terpenes*. They are found in natural resins and in various essential oils.

The terpenes have been the subject of much investigation by Berthelot, Tilden, Wallach and other chemists, the result of whose researches has been to show that a fairly large number of terpenes exist and to enlarge our knowledge of their constitution. Berthelot was one of the first to point out that French turpentine was somewhat different from American turpentine, and that Russian turpentine differed from both. He named the hydrocarbon of American turpentine, australene; that from French turpentine, terebenthene; and that from Russian turpentine, sylvestrene. Armstrong has shown that American turpentine is a mixture of two terpenes, one of which is identical with that of French turpentine, while the other is the same as that found in a Burmese pine tree, *Pinus Khasyana*.

Wallach describes nine terpenes, which he names as follows: 1. Pinene; this is the main constituent of French and American turpentine, and will be found described below. 2. Camphene; this is a solid terpene, a feature in which it differs from all other terpenes. It is prepared artificially from pinene. 3. Fenchene is also an artificial terpene. 4. Cimonene; found in essential oils belonging to plants of the family *Aurantiaceæ*, such as oils of lemon, orange, bergamot, etc. 5. Dipentene; found in oil of camphor, Russian and Swedish turpentine, etc. 6. Sylvestrene; the characteristic terpene of Russian turpentine and Swedish turpentine. 7. Phellandrene, which is found in various essential oils. 8. Terpinene; found in several essential oils. 9. Terpinolene; a rather rare terpene. Of these it will only be necessary to speak of pinene and sylvestrene, which are found in the chief commercial turpentines.

*Pinene* is a colourless or water-white mobile liquid, having a peculiar and characteristic odour. Its specific gravity according to Tilden is 0·8749. Wallach gives it as 0·860. It boils at from 155° to 156° C. When dry hydrochloric acid gas is passed into it combination ensues, and a crystalline body, very closely resembling camphor in appearance and odour, is obtained. This substance, by heating with caustic potash under pressure, yields the solid terpene, camphene. When pinene is exposed to sunlight in the presence of water a crystalline oxidation compound is formed, which has been named by Armstrong sobrerol, the composition being represented by the formula, $C_{10}H_{18}O_2$. There is also a tendency to form a crystalline hydrate, $C_{10}H_{16}3H_2O$, which is soluble in alcohol, insoluble in turpentine, slightly soluble in water, and sparingly soluble in ether, chloroform and carbon bisulphide.

One of the chief properties of the terpenes is their activity to polarised light, which they rotate more or less. There are two varieties of pinene, which differ from one another solely in the direction in which they rotate polarised light. One turns it to the right, and is known as dextro-pinene; the other rotates it to the left, and is known as lævo-pinene. The latter is found in French turpentine, while the former is the chief constituent of American turpentine, which is a mixture of both pinenes in variable proportions. The air oxidation products, the sobrerols, from these two pinenes have also similar differences of right and left handedness. A mixture of the two pinenes in equal proportions would not have any rotatory effect and would be optically inactive.

*Sylvestrene* is the characteristic terpene of Russian and Swedish turpentine derived from the Scotch fir, *Pinus sylves-*

*tris.* It is a colourless or water-white liquid, having a specific gravity of 0·846 at 20° C., and boiling at 175° C. It has a dextro-rotatory action on polarised light. Dry hydrochloric acid gas when passed through sylvestrene forms a liquid hydrochloride of the formula, $C_{10}H_{16}HCl$. When exposed to air and moisture it is more easily oxidised than pinene. The other pinenes are of no importance to the painter.

The properties of commercial French and American turpentines are so very similar that one description will suffice for both. Turpentine, as it is found in trade, is a water-white, limpid liquid, having a peculiar and characteristic odour which distinguishes it from other liquids. The specific gravity varies slightly from 0·864 to 0·870, the usual average being 0·867. French turpentine is usually more uniform in its gravity than American turpentine. It begins to boil at from 156° to 160° C., and is completely distilled at 170° C. If the sample be a fresh one there will be but a slight residue left on distillation. Old samples, however, may leave from 2 to 5 per cent. of a resinous residue.

Turpentine is readily combustible, burning with a smoky flame and evolving a characteristic odour. Turpentine has a flashing point of 97° to 100° F. (36° to 38° C.).

Turpentine is readily miscible with ether, alcohol, carbon bisulphide, benzene, petroleum spirit; it is insoluble in water. It is a good solvent for fats, oils, waxes, resins and similar products.

On exposure to the air turpentine absorbs oxygen slowly and becomes thick, viscid and fatty in appearance. Finally, on prolonged exposure, it forms a hard resinous substance. In thin layers, such as are formed in painting, there is less oxidation, as a larger proportion of the turpentine evaporates off. The oxidation of the residue is, however, more complete, and a hard resinous coat is left behind. This property distinguishes turpentine from all other spirituous solvents of a similar character; these evaporate away completely without leaving any residue behind, so that for painting purposes they are not so good as turpentine. Of the two varieties of turpentine American has greater absorbing properties than French.

Sulphuric acid in the cold has little action on turpentine. If the two bodies are repeatedly distilled together under a reflux condenser the turpentine becomes polymerised. Generally two bodies are formed. One of these has been named terebene. It has the same formula as turpentine, $C_{10}H_{16}$, but has a boiling point of 100° C. The other has been named colophene. It has the formula, $C_{20}H_{32}$, boils at 300° C., and is the main product of the reaction. This property of polymerisation distinguishes turpentine from such bodies as petroleum spirit, naphtha, etc.

Nitric acid acts very energetically on turpentine. If the acid is strong, the turpentine is often set on fire. The products which are obtained vary with the strength of the acid, temperature, etc., but are essentially oxidation products.

Chlorine, bromine and iodine act with great energy on turpentine—combustion often ensuing.

Turpentine has a rotatory action on polarised light—a property which distinguishes it from benzene, petroleum spirit and rosin spirit. French turpentine rotates the ray to the left; as measured in a polarimeter the rotation is − 30. This is fairly constant, showing that French turpentine has a uniform composition. American turpentine rotates the ray to the right, the specific rotation being on an average + 12. It varies, however, from + 8 to + 16, which points to its containing both a lævo and dextro terpene, the proportion of which varies from time to time.

Russian turpentine resembles American turpentine in many of its properties, such as its solvent properties, the action of sulphuric and nitric acids, etc. It is rather more variable in specific gravity, which may range from 0·862 to as high as 0·873. It begins to boil at 156° C., but is not completely distilled at 180° C., the great bulk of the spirit passing over at from 172° to 174° C. This greater range of temperature in distilling points to the fact that Russian turpentine is more complex in its composition than American or French turpentine. It has an odour resembling that of American turpentine, but differing slightly therefrom. It is rather more volatile in its character, is more prone to oxidation and on exposure to the air becomes viscid. Kingzett gives the formula, $C_{10}H_{14}O_4$, to the oxidation product and camphoric peroxide. This on heating with water gives rise to camphoric acid, $C_{10}H_{16}O_4$, and hydrogen peroxide, $H_2O_2$. On this property of Russian turpentine is based its use in the preparation of "Sanitas," a disinfectant.

Russian turpentine exerts a dextro-rotatory action on polarised light, the specific rotation varying from + 15 to + 23, which shows that it varies in composition.

Turpentine is frequently adulterated, the adulterants usually employed being petroleum spirit, shale naptha, rosin spirit and coal-tar naphtha. The fact of the adulteration and the nature of the adulteration is easily ascertained, but it is not so easy to ascertain the extent of the adulteration as it is very difficult to separate the adulterants added from the turpentine.

The specific gravity may be applied as a test for the purity of turpentine. That of pure turpentine may be taken as 0·867. If the sample has a lower gravity it points to the addition of petroleum spirit or shale naphtha. If higher to the addition of rosin spirit. Coal-tar naphtha has little influence on the gravity.

The temperature at which the sample boils and distils is a valuable test for turpentine. If the sample distils below the boiling point of water then petroleum spirit or shale naphtha has been added. If the sample boils above the boiling point of water and the temperature of distillation ranges to beyond 180° C. then coal-tar naphtha or rosin spirit have been added. See *Benzoline, Coal-tar Naphtha, Rosin Spirit, Shale Naphtha.*

Turpentine is largely used in the manufacture of paints and varnishes for the purpose of thinning them down and acting as a solvent for the oils and resins used in the preparation of those bodies.

**TURPENTINE SUBSTITUTES** have been brought out of late years under various fancy names, "patent turpentine," "turpenteen," "turpentyne," etc. The composition of these bodies necessarily varies. Some are simply derivatives of petroleum or shale spirit, having a rather heavier gravity than benzoline or shale naphtha. Others are mixtures of rosin spirit, turpentine and petroleum spirit. Some contain small quantities of rosin. They are more or less efficient substitutes, but whether they are good or bad depends on their composition.

## U.

**ULTRAMARINE** is one of the most important blue pigments at the disposal of the painter. At one time it was obtained solely from natural sources, being derived by a complex process from the rare mineral lapis lazuli. It is still prepared in small quantities from this source for the use of artists, but the great bulk of the ultramarine of commerce is manufactured artificially. Natural ultramarine usually contains 35·8 per cent. of silica, 34·8 per cent. of alumina, 23·2 per cent. of soda, 3·1 per cent. of sulphur, and 3·1 per cent. of calcium carbonate; but its composition is liable to vary from time to time. Natural ultramarine is a pigment of a fine bright blue tint. It works well in oil or water, and is quite permanent when exposed to all ordinary conditions of the atmosphere. It is decomposed by acids, but not affected by alkalies.

Artificial ultramarine is made by furnacing a mixture of silica, china clay, sulphur, soda, sodium sulphate, rosin; these ingredients being mixed together in various proportions according to the character of the ultramarine being made, *viz.*, two chief varieties of ultramarine may be distinguished, *sulphate ultramarine,* known by its pale greenish-blue tint and ready decomposition by acids; and *soda ultramarine,* which is the principal variety made. Of this there are two kinds, one made with a large percentage of silica, which is not affected in tint by being mixed with alum; the other contains less silica, but is reddened in tone by alum. The former is much used by paper makers and is generally known as paper-makers' ultramarine. Several qualities of ultramarine are made varying in depth of tone, tint, fineness and other qualities. These suit different purposes. Thus the paper-maker requires a fine grade of ultramarine which will not be altered in tint by alum which he uses in his size; the lithographic printer requires a very fine grade of ultramarine; the calico printer also wants a fine ultramarine, free from grit, so that the lines of his engraved roller will not become clogged up; the painter desires a bright shade, but he does not require so fine a texture as the printer; the laundress also uses ultramarine—a common quality will as a rule suit her purpose.

Ultramarine is a blue pigment of an exceedingly bright character, varying in tint from a pale greenish blue to a violet blue. It works well with all vehicles and, hence, is very extensively used as a pigment, in oil painting, water painting, distemper work, fresco work, printing of all kinds, laundry purposes, etc. When exposed to all ordinary atmospheric conditions it is quite permanent, which is a most important feature of ultramarine. Its most characteristic property is that when treated with acids, even very dilute ones, it is decomposed, the colour is destroyed, sulphuretted hydrogen is evolved, and a white precipitate of sulphur is deposited. No other blue behaves in the same manner, so that the action of acids constitutes a good test for ultramarine. If the pigment be boiled with a little strong nitric acid, the first action is to decolourise it and to give rise to a deposition of sulphur in the form of a white precipitate. On continuing the boiling the sulphur gradually becomes dissolved, being transformed into sulphuric acid, and a gelatinous residue of silica is left behind. On addition of ammonia to a portion of the acid solution a white gelatinous precipitate of alumina is thrown down; while the addition of barium chloride to another portion results in a white precipitate of barium sulphate. Ultramarine is unaffected by boiling with alkaline solutions of any kind. Some varieties of ultramarine are reddened in tone by being mixed with a solution of alum or alumina sulphate.

Ultramarine, containing sulphur as one of its ingredients, cannot be mixed with white lead, chrome yellow or other lead pigments without risk of discolouration from the combination of the sulphur of the blue with the lead of the other pigment to form the black sulphide of lead. Copper pigments are affected much in the same way, the black sulphide of copper being formed. It should be said, however, that these changes do not always occur. Sometimes ultramarine may be mixed with chrome yellow or white lead without ulterior effect.

Ultramarine is a combination of silica, alumina, sodium and sulphur. The proportions in which these ingredients are combined varies somewhat as shown in the following analyses of various ultramarines :—

Analyses of Ultramarines.

| | Sulphate. | Soap Makers. | Calico Printers. | Paper Makers. | Green. |
|---|---|---|---|---|---|
| Silica, $SiO_2$ . . . . . | 49·68 | 40·64 | 40·88 | 45·42 | 38·52 |
| Alumina; $Al_2O_3$ . . . | 23·00 | 25·04 | 24·11 | 21·14 | 28·94 |
| Sulphur, S . . . . . . | 9·23 | 12·95 | 13·74 | 11·62 | 8·30 |
| Sulphur trioxide, $SO_3$ . | 2·46 | 4·81 | 3·04 | 5·57 | — |
| Soda, $Na_2O$ . . . . . . | 12·49 | 14·26 | 15·61 | 9·90 | 23·68 |
| Water, $H_2O$ . . . . . | 3·12 | 2·27 | 2·60 | 6·32 | — |

In what manner these constituents are combined together, in other words, what is the chemical constitution of ultramarine, is at present not known with certainty. Many theories have been propounded from time to time, but none can be said to offer a satisfactory solution to the problem.

Ultramarine is rarely adulterated ; it is too cheap. What is sometimes sold as lime blue is simply ultramarine, or perhaps, that pigment mixed with a little whiting or gypsum. Laundry blues also occasionally consist of ultramarine mixed with carbonate of soda.

Ultramarine should be examined for strength of colour, tint, etc., by the tests described under the head of *Testing Pigments.* The chemical tests have been described above. It may be added to those that no violent effervescence should be obtained on treating the blue with dilute hydrochloric acid, nor should the solution in nitric acid, after precipitating with ammonia, give a further precipitate on adding ammonium oxalate, showing the presence of lime. Water should extract but a small quantity of soluble salts from ultramarine.

Further, but a slight precipitate of sulphate of barium should be obtained on adding barium chloride to an hydrochloric acid solution.

**ULTRAMARINE GREEN.**—This pigment is not much used. It is obtained in the first stage of ultramarine making by what is known as the indirect process. In composition it resembles the blue ultramarine as will be seen from the analysis of a sample of green ultramarine given in the preceding article; it contains rather less sulphur. Its properties are identical with those of blue ultramarine.

**ULTRAMARINE RED** is a pigment prepared from ultramarine blue by treatment with chlorine. It is of more interest from a scientific point of view than a practical one. It is little, if at all, used in painting. Its properties are similar to those of blue ultramarine.

**ULTRAMARINE VIOLET** is, like the last, a pigment chiefly of scientific interest.

**UMBERS.**—These form a most important group of natural pigments found in many places, Devonshire, Derbyshire, Cumberland, Cyprus, etc. The best is that which is known as Turkey umber, but which is found in the island of Cyprus. They are brown pigments varying in shade from a yellow brown to a dark brown. There are two varieties, *raw umber*, which is the pigment as it is found, and *burnt umber*, the crude pigment heated in a furnace, whereby the colour or tint is rendered darker and warmer. In composition umbers resemble the ochres; they are natural earths coloured by oxide of iron and oxide of manganese. The following are some analyses of umbers:—

*Turkey or Cyprus Umber:—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 4·32 |
| Water, combined | 8·45 |
| Silica, $SiO_2$ | 29·56 |
| Calcium carbonate, $CaCO_3$ | 5·56 |
| Manganese, $MnO_2$ | 12·28 |
| Alumina, $Al_2O_3$ | 2·73 |
| Ferric oxide, $Fe_2O_3$ | 36·47 |

*Derbyshire Umber:—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 13·47 |
| Water, combined | 5·17 |
| Silica, $SiO_2$ | 4·43 |
| Calcium carbonate, $CaCO_2$ | 2·60 |
| Manganese, $MnO_2$ | 11·53 |
| Alumina, $Al_2O_3$ | 8·07 |
| Ferric oxide, $Fe_2O_3$ | 22·50 |
| Barium sulphate, $BaSO_4$ | 30·10 |
| Calcium sulphate, $CaSO_4$ | 2·15 |

*English Umber:—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 65·00 |
| Water, combined | 4·80 |
| Silica, $SiO_2$ | 12·30 |
| Manganese, $MnO_2$ | 10·00 |
| Ferric oxide, $Fe_2O_3$ | 6·30 |
| Lime, CaO | 0·60 |

*Ashburton Umber:—*

| | Per Cent. |
|---|---|
| Water, hygroscopic | 0·8 |
| Calcium carbonate, $CaCO_3$ | 46·70 |
| Magnesium carbonate, $MgCO_3$ | 41·0 |
| Silica, $SiO_2$ | 3·3 |
| Ferrous carbonate, $FeCO_3$ | 2·6 |
| Manganese carbonate, $MnCO_3$ | 2·5 |

Umbers are pigments of a warm brown colour, varying in tone or hue from yellowish to violet brown, the burnt umbers being darker and warmer in tone than the raw umbers. As pigments they work well in both oil and water. They form good staining colours, as their colouring power is strong. As body colours they vary considerably in quality. They are quite permanent on exposure to all ordinary atmospheric conditions. They mix well with all other pigments without themselves undergoing any change or bringing about any change in other pigments. They are, therefore, amongst the most valued of painters' colours.

Umbers are not readily attacked by acids, but prolonged digestion with strong hydrochloric acid will decompose them, a brownish-yellow solution being obtained containing the iron, alumina, manganese, lime, etc., present in the umber, while there will be an insoluble residue of silica or, in some cases, barium sulphate. Alkalies have no action on umbers. A chemical analysis of umbers, if required, may be made in the same manner as described under ochres.

As umbers vary somewhat in their value as pigments it is important to test them for colouring power, covering power, body, etc., in the usual way.

## V.

**VANDYKE BROWN.**—What the original pigment known by the name of Vandyke brown was like is not known; probably it was a natural earth of the type of the umbers, Cappagh brown, etc. At the present time three varieties of Vandyke brown may be met with in common use by artists and house painters.

1. Natural earths of a warm brown colour, resembling the umbers but generally containing a little more organic matter.

For use as pigments these natural earths simply require a thorough grinding. They are good pigments, work well in oil or water, and are permanent. In their general composition they resemble the umbers and answer to the same chemical tests.

2. Made by heating cork cuttings or waste, twigs of trees and other vegetable matter. Vandyke browns made in this way have a warm brown colour of a reddish hue. They mix very well with oil or water, have strong colouring properties, but are somewhat deficient in body.

Such a brown has a composition analogous to the following:—

| | Per Cent. |
|---|---|
| Organic matter and water | 70·29 |
| Calcium carbonate, $CaCO_3$ | 3·49 |
| Oxide of iron and alumina | 1·61 |
| Alkaline salts | 24·60 |

3. Many of the common Vandyke browns, especially those used by the house painter, are mixtures in various proportions of lamp black, Indian red or similar pigments, and necessarily partake of the properties of the pigments from which they are made. As a rule they work well in oil, are quite permanent, and have a better body than Vandyke browns made from vegetable matter.

**VEGETABLE BLACK.**—The name given to a very light variety of lamp black collected in the chambers at the farthest point from the oil furnace. It is almost pure carbon, containing but a small proportion of moisture and occluded gases. It is noted for its intense black colour and strong colouring power, and hence is used in making printing inks of fine quality. It is also employed in making the best black varnishes. Its properties are identical with those of lamp black and carbon black. See *Carbon Black*, *Lamp Black*.

**VENETIAN RED.**—The name given to a red pigment made by heating ochres. It has a light red colour, works well in oil or water, generally possesses good covering powers and body, but is somewhat deficient in colouring power. It is largely used in house painting.

In its general chemical composition and properties it resembles the ochres. See *Ochres*, *Oxide Reds*.

**VERDIGRIS.**—This compound, at one time largely used as a pigment, but now almost entirely obsolete for that purpose, is the basic acetate of copper. It is a pale greenish-blue pigment, poor both in colouring power and body. It is not permanent when exposed to the air.

Verdigris generally has a slight acid odour. It is insoluble in water, but dissolves in acids with a pale greenish tint. On adding ammonia to this solution the characteristic deep blue colour of ammoniacal copper solutions is obtained. On heating with dilute sulphuric acid the odour of acetic acid is evolved. Verdigris should answer to the following tests: It should dissolve in hydrochloric acid without effervescence. On adding sulphuretted hydrogen to this solution a black precipitate of copper sulphide should be obtained. On filtering this off and adding in succession to the filtrate ammonia, ammonium sulphide, ammonium carbonate and ammonium phosphate, no further precipitate should be obtained. On adding barium chloride to the acid solution there should be no white precipitate of barium sulphate.

**VERDITER.**—This pigment is a basic carbonate of copper, prepared by precipitating copper sulphate or some other copper salt by means of carbonate of soda. It is a pigment of a pale greenish hue, deficient in colouring power and body; hence it is now rarely used as a pigment, the introduction of the Brunswick greens having caused it to become obsolete. Verditer can be recognised by, and should answer to, the following tests: It dissolves completely in hydrochloric acid with effervescence. On adding ammonia to this solution the deep azure blue solution characteristic of copper will be formed. On passing a current of sulphuretted hydrogen gas through the acid solution a black precipitate of copper sulphide will be obtained. On filtering this off and adding in succession ammonia, ammonium sulphide, ammonium oxalate, and ammonium phosphate, there should be no further precipitate. Barium chloride should not throw down a precipitate from the aqueous solution.

**VERMILION.**—This important pigment is the sulphide of the metal mercury, and has a composition corresponding to the formula HgS. It is prepared by subliming a mixture of mercury and sulphur and by heating a mixture of mercury and sulphur with an aqueous solution of caustic potash.

Vermilion is a pigment of a fine scarlet-red colour. It is heavy, the specific gravity being 8·2. It possesses good body and colouring powers. It is a fairly permanent pigment when used with oil. If used as a water colour it tends to turn brown on exposure to the air. Its great weight causes it to have one disadvantage, that is, to settle out in the paint cans.

Vermilion has the following properties: When heated it is volatile. If the heating is done in a closed tube the vermilion will sublime on the cold portions of the tube. If the heating be done with access of air the vermilion burns with the pale blue lambent flame of sulphur. Treated with acids it does not dissolve; a mixture of nitric and hydrochloric acid will dissolve it, giving rise to a colourless solution of mercury chloride. Alkalies have no action on vermilion.

Vermilion should answer to the following tests: Heated on the lid of a porcelain crucible little or no residue should be left behind. Treated with hydrochloric acid the colour should not alter in any way and the acid should remain quite colourless These tests will be found sufficient to determine the purity of any sample of vermilion.

**VERMILIONETTES.**—As their name indicates these pigments are intended to act as substitutes for vermilion. Since their introduction they have become of considerable importance to the painter, and are very extensively used where a cheap bright red pigment is required.

Vermilionettes vary very much in their composition. They can be, and are, made of a great variety of tints, from a pale rose to a deep scarlet. They owe their colour to eosine, a coal-tar dye which possesses the property of forming lakes with lead and alumina salts, and consequently can by their means be thrown down on to a base. Some vermilionettes are made with barytes alone, others with a mixture of barytes and orange lead, some are made with gypsum. The proportion of eosine may range from 1 per cent. in pale vermilionettes to 4 per cent. in deep vermilionettes.

Vermilionettes, owing to their varying composition, vary very much in body and covering power. Some cover very well and have good body. Others are somewhat deficient in these properties. All, however, possess strong colouring powers. Their tints are as a rule very bright. They work well in either oil or water. They are not permanent pigments, exposure to air soon causing them to fade. Those made with lead salts are, however, faster than those made with alumina salts. Used as oil paints they are faster to light than when used as water colours. They do not mix well with spirit and so do not make satisfactory enamel paints.

When mixed with alcohol or methylated spirit vermilionettes tend to give up their colour to the spirit. The solution thus obtained will have a rose-red colour when looked through, but a peculiar and characteristic bloom or fluoresence when looked at—this fluoresence varying according to the particular kind of eosine used in making the vermilionettes. This is a most characteristic test for these pigments.

When vermilionettes made from barytes, gypsum or some other white base are heated in a crucible they lose their colour, a white or faintly coloured residue only being left behind. If they contain orange lead then a red residue will be left behind. Vermilionettes made with orange lead turn dark in colour when mixed with dilute nitric acid.

Pigments of a similar character to vermilionettes are made and sold as Royal reds, Imperial red, Victoria red, Signal red, Post Office red, etc.

The painter will require to examine the supplies of vermilionettes he purchases for colouring power, tint, covering power and body in the usual way. It will not be necessary for his purpose to subject them to any chemical tests.

The manufacturer may desire to be able to ascertain from what materials a particular sample of vermilionette has been made. This is by no means easy, and it is somewhat difficult to give directions which will cover every case. The following may be taken as hints as to the manner of proceeding: In order to ascertain the kind of the colouring matter, the process is to treat a sample of vermilionette with alcohol and to observe the character of the fluorescence, as also the tint of the solution obtained.

The mineral portion of the pigment may be examined for lead, alumina, barytes, orange lead, by the ordinary methods of chemical analysis. The following notes may serve as a guide. If orange lead be present the pigment turns dark brown on treatment with dilute nitric acid. On digesting it with strong nitric acid for some time the red colour gradually disappears and on diluting with water a colourless solution will be obtained. On adding ammonia and ammonium sulphide to this a copious black precipitate is formed. If the vermilionette has been made with lead acetate or lead nitrate simply on a base of barytes or other white pigment, it will be found in this acid solution, but only a slight black precipitate will be obtained on adding ammonia and ammonium sulphide. If barytes has been used in making the sample it will be left behind on treatment with acids, and it will tinge the Bunsen flame a yellow-green colour. If gypsum has been used then the flame will be tinted a reddish colour. Sometimes these pigments are made with sulphate of lead. In this case the base will be left behind on treatment with nitric acid, but will be dissolved by boiling with hydrochloric acid. The solution will deposit lead chloride on cooling and give a precipitate of barium sulphate with barium chloride. If white lead or whiting has been used in making them the sample will effervesce on treatment with the acid and lime or lead will be found in the solution. If zinc white has been used then it will be soluble in dilute sulphuric acid, and the solution will give a white precipitate on adding ammonia and ammonium sulphide.

For the principal eosines and their characteristics, see *Eosine*.

**VERONA EARTH, VERONA GREEN.**—Names given to a natural green pigment found near the town of Verona in Italy. It is not used now.

**VICTORIA GREEN.**—This name has been given to Brunswick green. See *Brunswick Green*.

**VICTORIA RED.**—This name has been given to a pigment made from eosine. It resembles vermilionette in composition and properties. See *Vermilionettes.*

**VIENNA LAKE.**—A name given to crimson lake. See *Crimson Lake.*

**VIOLET LAKE** is a pigment prepared from a coal-tar colour, usually by precipitating with tannic acid on a base of barytes. See *Aniline Lakes.*

## W.

**WALNUT OIL.**—This oil is expressed from the kernels of the well-known walnut, the fruit of the tree known to botanists as *Juglans regia.* The walnut gives a large proportion, over 50 per cent., of a clear, bland and sweet oil of a pale straw colour with a tinge of green. It can readily be obtained almost colourless. The specific gravity varies from 0·925 to 0·927. It begins to be turbid at a temperature of − 15° C. and becomes solid at a temperature of − 27·5° C. Strong sulphuric acid causes the evolution of some heat, the increase in temperature being about 101° to 103° C. Walnut oil absorbs a large proportion of iodine, about 144 per cent.; hence it must contain linolic or linolenic acids in large proportion. It requires 19·6 per cent. of caustic potash to saponify it.

It is a powerful drying oil, fully equal, if not superior, to linseed oil. It is chiefly used by artists, as, on account of its freedom from colour, it does not affect the tone of delicate tints so much as linseed oil does. Its greater cost prevents it from coming into use for house painting.

**WELD SEED OIL.**—The seeds of the dyer's weld, *Reseda luteola*, yield an oil of a dark green colour, rather limpid, with a nauseous odour and taste, having a specific gravity of 0·936. It possesses fairly good drying properties. The weld is now very rarely grown, as the dye it yields has been largely displaced by coal-tar colours; consequently the oil is a rare article.

**WHITE LEAD.**—White lead is probably the most important pigment used by the painter. It enters into the composition of a great variety of paints, both alone and in combination with other pigments. It possesses all the properties of a perfect pigment. It has a good colour, strong colouring powers, great opacity (and, therefore, has good body), and good covering powers, while it works well under the brush. In all these qualities it excels nearly all other pigments; consequently it is considered to be the type of a pigment.

White lead is the basic carbonate of lead, having a composition approximating to the formula $2PbCO_3$, $PbH_2O_2$, that is, it contains two equivalent proportions of lead carbonate and one equivalent of lead hydroxide. White lead is, however, not always of a definite composition, but varies somewhat. One approximating to the formula given above contains:—

68·95 per cent. of lead carbonate, $PbCO_3$.
31·05 per cent. of lead hydroxide, $PbH_2O_2$.

Or put in another way:—

86·32 per cent. of lead oxide, PbO.
11·36 per cent. of carbonic acid, $CO_2$.
2·32 per cent. of water.

The following are some analyses of white lead made by various processes, which show that there is some variation from the above normal standard in commercial samples:—

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Lead monoxide | 86·80 | 86·24 | 83·77 | 86·35 | 85·93 | 82·81. |
| Carbonic acid . | 11·16 | 11·68 | 15·06 | 10·46 | 11·89 | 14·20. |
| Water . . | 2·00 | 1·61 | 1·01 | 2·95 | 2·01 | 3·00. |

Nos. 1 and 2 are white leads prepared by chamber methods. They are of good quality.

No. 3 is a Kremnitz white prepared by precipitation with carbonic acid. It is deficient in covering power owing to its containing too much lead carbonate.

No. 4 is a Dutch process white lead of English make of good quality.

No 5 is a white lead of poor quality prepared by precipitation with sodium carbonate.

No. 6 is a white lead prepared by Gardner's process. This is of excellent quality.

White lead is made by a variety of processes. The oldest and the one which yields the best pigment is the so-called Dutch or stack process. This consists in building in a brick shed, constructed for the purpose, tiers or layers of spent tan, earthenware pots containing acetic acid and rolls of sheet lead, cast plates of lead, boards. These are alternated in layers until the shed is full, when they are left for three months. At the end of this time the metallic lead will have been corroded into white lead, which is then collected and undergoes a finishing process.

White lead is also made by placing plates of lead on shelves in a chamber and treating them with currents of air, carbonic acid gas, acetic acid, steam, etc., in various ways. It is also made by precipitating solutions of basic acetate of lead with carbonic acid gas or with solutions of alkaline carbonates. All these various processes are susceptible of modification and have received such at the hands of many inventors.

White lead is sold in two forms, (1) a white powder and

(2) a paste with linseed oil, the latter being generally known as ground white lead. The amount of linseed oil usually present in such is 7 to 8 per cent.

White lead is a fine white powder, having a specific gravity of 6·47 and weighing about 180 lb. to the cubic foot. Occasionally heavier white leads are met with.

White lead is soluble in dilute nitric acid and in acetic acid with effervescence, due to the liberation of carbonic acid gas. Boiled with strong hydrochloric acid white lead dissolves and carbonic acid is evolved. The solution on cooling deposits small crystals of lead chloride. Sulphuric acid decomposes white lead, insoluble lead sulphate being formed. Boiled with solutions of caustic potash or caustic soda white lead dissolves.

Solutions of white lead in nitric or acetic acids give white precipitates of the sulphate with sulphuric acid, of the chloride with hydrochloric acid, of the hydrate with ammonia, and of the basic carbonate with alkaline carbonates. Sulphuretted hydrogen throws down a black precipitate of lead sulphide. Potassium bichromate in neutral solutions throws down a yellow precipitate of chrome yellow (lead chromate).

White lead should answer to the following tests: It ought to be completely soluble in dilute, pure nitric acid. On exactly neutralising this solution with soda, passing a current of sulphuretted hydrogen through the solution and filtering off the precipitate of lead sulphide which forms, the filtrate ought to give no further precipitate on the addition in succession of ammonia, ammonium sulphide and ammonium carbonate.

As a pigment white lead possesses all the good qualities desired by a painter, *viz.*, good colour, strong colouring powers, body, covering power and permanency. It is distinguished from all other pigments by the ease with which it mixes with oil, forming a paint which flows freely from the brush. This feature is generally ascribed to the white lead containing hydroxide of lead, which possesses basic properties and combines to a greater or less extent with the oil so as to form a kind of varnish in which the remaining constituents of the white lead are united as of an emulsion. It is for this reason that white lead is used in the manufacture of so many paints as what is known as a "body colour," the ingredient to which paint owes its body and covering power. Scarcely any other pigment has this property of forming an intimate union with the oil. Mr. J. B. Hannay denies that this union takes place. No positive proofs that it does so are available. As negative proofs it may be pointed out that occasionally white lead has been known in process of time to lose its opacity and become transparent, due to the increase in the degree of combination between the oil and the pigment; that solvents like ether and petroleum ether do not extract all the oil from ground white lead, especially when the latter has been kept for some time. The residual oil must, therefore, be combined with the lead, as otherwise it would be extracted by the solvent.

When exposed to light and air white lead is permanent. If, however, it be exposed to sulphuretted hydrogen gas or sulphurous gases it turns brown, a change due to the formation of lead sulphide by combination between the sulphur and the lead of the paint. This alteration is more likely to take place in towns like London, Manchester and Birmingham, where there is much coal burnt, the sulphur in which goes to contaminate the atmosphere of the towns.

White lead may be mixed with most other pigments. The only exceptions are those which (like cadmium yellow, ultramarine, antimony, vermilion) contain sulphur. With these there is always a risk of discolouration from the formation of lead sulphide.

White lead is frequently adulterated, the usual adulterant being barytes, because this is the only white pigment which is cheaper and at the same time approaches white lead in regard to relative weight. As a matter of fact this adulteration of white lead with barytes is a recognised custom of the white lead trade, the makers preparing several brands which they distinguish as "genuine," "No. 1," "No. 2," and so on. This system is well known to users, who pay a lower price for the adulterated samples than for genuine white lead. The detection of barytes in white lead is comparatively easy, seeing that it is left as an insoluble residue on treating the sample with dilute nitric acid and the residue gives the reactions for barytes (see *Barium Sulphate*). It may be pointed out here that strong nitric acid will not dissolve white lead, but decomposes it, forming lead nitrate, which, being insoluble in the acid solution, is precipitated. On diluting with water this dissolves and, if the white lead be pure, a clear solution will be obtained. Commercial nitric acid often contains small quantities of sulphuric acid. Such acid should not be used, as it will not completely dissolve white lead, owing to the formation of some insoluble lead sulphate.

Ground white lead may be examined in the following manner: Boil a little of the sample with strong nitric acid. This decomposes the white lead, forming lead nitrate, while the oil is destroyed more or less. On diluting with water, if the lead be pure, a clear solution will be formed, or at most a few oily particles will float about. Any barytes which may have been added to it will be left as an insoluble white residue. Should it be necessary to ascertain the amount of barytes in a sample of either dry or ground white lead weigh out 2 grammes and boil with nitric acid until the lead is thoroughly decomposed, then dilute with water, filter from any insoluble portions, wash well with warm water, then dry it, burn in a weighed crucible and weigh the residual barytes. The weight so obtained multiplied by fifty gives the percentage of barytes in the sample.

**WHITING.**—This pigment is prepared from chalk. Chalk is a natural deposit of calcium carbonate, very extensively developed in the south-eastern counties of England, where it forms what are known as the North and South Downs. It is also found in the North of France. It is curious to note that chalk is almost unknown in the United States. When chalk is examined under the microscope it is seen to consist of minute shells, the remains of a group of animals known as *Foraminifera*, of which there are many species. These form a skeleton of calcium carbonate. They live on the surface of the sea. When they die, their shells fall to the bottom and there form a deposit. In the ancient cretaceous seas they occurred in great abundance, and the deposits then formed now yield chalk. Whiting is nothing more than the chalk ground up and levigated with water. Spanish white and Paris white are also prepared from chalk in the same way as whiting. They are, however, of finer quality.

Whiting is a dull white powder of an amorphous form, soft to the feel, the specific gravity of which is 2·6. It is insoluble in water. Most acids dissolve it with effervescence and evolution of carbonic acid. On this account it is largely employed as a source of carbonic acid, especially by aerated water manufacturers. It consists chiefly of calcium carbonate, $CaCO_3$, but it may also contain traces of silica, oxide of iron, water, etc. The following analysis shows the composition of the whiting usually on the market :—

| | | |
|---|---|---|
| Calcium carbonate, $CaCO_3$, | 94·79 | per cent. |
| Silica, $SiO_2$ . . . . | 3·03 | ,, |
| Water . . . . | 2·17 | ,, |

When heated to a strong red heat whiting is decomposed, carbonic acid is evolved, and a residue of quicklime left behind.

Whiting should answer to the following tests: On treatment with dilute hydrochloric acid it ought to almost completely dissolve with effervescence, a slight insoluble residue of silica being left. The solution should give no precipitate on the addition of ammonia (a faint gelatinous precipitate of alumina is sometimes formed). Ammonium sulphide should give no precipitate. On the addition of ammonium oxalate to the ammoniacal solution a white precipitate of calcium oxalate is obtained. On filtering this off and adding sodium phosphate to the filtrate no further precipitate should be obtained.

The amount of calcium carbonate, whiting, in any pigment may be ascertained by dissolving it in hydrochloric acid, adding a slight excess of ammonia and then ammonium oxalate and filtering off the precipitate thrown down; the precipitate of calcium oxalate is washed with warm water, dried and burned in a crucible. The burning converts the calcium oxalate into calcium carbonate, which is then weighed.

As a pigment whiting is mostly used as a body colour in distemper work, colouring ceilings, walls, etc., using water as a vehicle. It is not used as an oil colour, for it is subject to the defect that when mixed with oil it loses its opacity and colour, becoming a greyish yellow in tint. Mixed with about 18 per cent. of linseed oil it forms the very useful article known as putty. It is quite permanent when used as a pigment, resisting exposure to all ordinary atmospheric conditions.

It mixes fairly well with most pigments, the only exce tions being those pigments which, like Prussian blue, chr yellow, emerald green, are affected by alkaline substa

Whiting often has an alkaline reaction due to its being overheated in drying.

A fine carbonate of lime is sometimes obtained as a bye-product in many chemical operations. Such may be used for painting purposes in place of the natural whiting, while for the making of cement and some other uses the artificial has advantages over the natural variety.

**WILKINSON'S BLUE.**—A Prussian blue named after the maker.

**WILKINSON'S WHITE LEAD.**—This pigment (now out of use) is an oxychloride of lead prepared by treating litharge with a solution of salt. It was too irregular in composition to be of much service as a pigment.

**WOOD NAPHTHA.**—This product is obtained in the distillation of wood. It is a liquid of somewhat complex composition. The principal ingredient is methyl alcohol, of which the proportion varies from 50 to 90 per cent. There is also present acetone, allyl alcohol, furfurol, various ketones, etc. It has a somewhat unpleasant odour and nauseous taste, both of which are due to the impurities present in the naphtha. It volatilises on exposure to the air, burns with a slightly luminous flame, and mixes with water in all proportions. It is a good solvent for resins and gums; hence it is used in the preparation of varnishes. Its solvent properties are somewhat greater than those of ordinary alcohol, a fact which may be ascribed to the presence of acetone and one or two other bodies in small quantities in the naphtha.

When mixed with caustic soda wood naphtha produces a dark brown colour. Sulphuric acid gives a red colour and noted.

mercurous nitrate a grey precipitate of mercury. None of these reactions are given by pure methyl or ethyl alcohols. See also *Alcohol, Methyl Alcohol, Methylated Spirit.*

## Y.

**YELLOW OCHRE.**—A natural pigment of an earthy nature, containing hydrated oxide of iron as the colouring principle. See *Ochre.*

**YELLOW LAKE** is usually prepared by making a decoction of Persian berries and precipitating with solution of alum and soda. It is a combination of the colouring principle of the berries with alumina. It is not much used because, like almost all lakes, it has little body, and because it is somewhat deficient in colouring power and fugitive on exposure to light and air.

## Z.

**ZINC** is a very useful metal. It is found in nature in the form of sulphide as the mineral zinc blende; also as carbonate in the form of calamine. From these minerals it is obtained by heating in a furnace with reducing agents. Zinc is a silvery grey metal, rather brittle at the ordinary temperature, but more elastic and ductile when heated. At a temperature of 420° C. it melts, and at 1040° C. it boils and becomes volatilised. Its vapour is combustible, burning with a peculiar greenish flame and forming zinc oxide. The specific gravity of zinc is 6·8 to 7. It is but slightly oxidised when exposed to the air. It is easily soluble in acids and alkaline solutions. Its salts are numerous and useful in many chemical operations. With the exception of the chromate, which is derived from a coloured acid, all zinc salts are white. The oxide is insoluble in water, as also are the sulphide, carbonate, phosphate and a the solution. It is readily soluble in water, forming a colourless solution, and is much used for a variety of purposes, medicinal and otherwise. It should answer to the same tests as zinc chloride, except that it should not give a precipitate with silver nitrate. With barium chloride it gives a white precipitate of barium sulphate. It is used in colour making for the preparation of zinc chrome and zinc green.

**ZINC SULPHIDE.**—This compound of zinc and sulphur, which has the formula $ZnS$, occurs naturally as the mineral blende. It can also be made artificially by precipitating solutions of zinc with alkaline sulphides, when it is thrown down as a white amorphous precipitate. It is soluble in acids with evolution of sulphuretted hydrogen, and that solution gives the tests for zinc as described above. Zinc sulphide forms the basis of a few pigments such as Orr's zinc white, Charlton white, lithophone, etc. When used as a pigment it ought to be of a good white colour, not yield anything to water on being digested with it, should be completely soluble in hydrochloric acid, and the solution should not contain any lime or magnesia. It is employed in colouring rubber on account of the fact that it is not discoloured by the sulphur with which the rubber is mixed. Commercial zinc sulphide usually contains from 97 to 98 per cent. of the sulphide, the rest being water.

**ZINC WHITE** is one of the most important pigments at the disposal of the painter. It is manufactured by burning the vapour of metallic zinc and collecting the fumes of oxide thus formed in suitable chambers. Zinc white is the oxide of zinc, and has a composition corresponding to the formula $ZnO$. It has a faint bluish-white colour. It is very bulky. Its colouring power is fairly strong, and its covering powers are great, but its body is deficient, owing to its voluminous nature. Many attempts have been made to remedy this defect, the best method being to grind the pigment under an edge runner for some time. It mixes well with oil, although it takes a large proportion, about 22 per cent., to form the usual paste colour. It works well also with water, and is supplied to water colour artists under the name of Chinese white. It is quite permanent when exposed to light and air, and is not affected by sulphuretted hydrogen or sulphur compounds. It may, therefore, be used in places where white lead is not available. It is largely used for colouring india-rubber goods, being one of the best bodies which can be so employed. When heated it turns yellow, but regains its whiteness on cooling.

The chemical properties of zinc white have been given under *Zinc Oxide*. Zinc white is sometimes adulterated. The fact of such adulteration is easily detected, for pure zinc white should dissolve completely in dilute sulphuric acid without any effervescence. Any adulterant will not completely dissolve, or there may be some effervescence. To ascertain the amount of zinc white or oxide of zinc in a pigment dissolve about 2 grammes in sulphuric acid and water, filter off any insoluble portion, and add to the solution first ammonia (to render it alkaline) and then ammonium sulphide. This will throw down all the zinc as white sulphide of zinc. Filter this off and wash well with water, dry it, then burn it in a crucible when it changes to oxide. When burned this is weighed and its weight gives the amount of zinc white or zinc oxide present in the sample.

When a pigment is sold simply as zinc white the oxide of the metal is understood. Sometimes the sulphide and pigments containing it are sold as zinc whites. See *Orr's White*, *Zinc Sulphide*.

**ZUMATIC DRIER.**—Under this name has been sold a mixture of zinc white and borate of manganese.

# APPENDIX A.

## Comparison of Baumé Hydrometer and Specific Gravity for Liquids Lighter than Water.

(American Scale.)

| Degrees Baumé. | Specific Gravity. | Degrees Baumé. | Specific Gravity. | Degrees Baumé. | Specific Gravity. |
|---|---|---|---|---|---|
| 10 | 1·000 | 33 | 0·862 | 56 | 0·758 |
| 11 | 0·993 | 34 | 0·857 | 57 | 0·754 |
| 12 | 0·986 | 35 | 0·852 | 58 | 0·750 |
| 13 | 0·979 | 36 | 0·847 | 59 | 0·746 |
| 14 | 0·973 | 37 | 0·842 | 60 | 0·742 |
| 15 | 0·966 | 38 | 0·837 | 61 | 0·738 |
| 16 | 0·960 | 39 | 0·832 | 62 | 0·735 |
| 17 | 0·953 | 40 | 0·827 | 63 | 0·731 |
| 18 | 0·947 | 41 | 0·823 | 64 | 0·727 |
| 19 | 0·941 | 42 | 0·818 | 65 | 0·724 |
| 20 | 0·935 | 43 | 0·813 | 66 | 0·720 |
| 21 | 0·929 | 44 | 0·809 | 67 | 0·716 |
| 22 | 0·923 | 45 | 0·804 | 68 | 0·713 |
| 23 | 0·917 | 46 | 0·800 | 69 | 0·709 |
| 24 | 0·911 | 47 | 0·795 | 70 | 0·706 |
| 25 | 0·905 | 48 | 0·791 | 71 | 0·702 |
| 26 | 0·900 | 49 | 0·787 | 72 | 0·699 |
| 27 | 0·894 | 50 | 0·783 | 73 | 0·696 |
| 28 | 0·889 | 51 | 0·778 | 74 | 0·692 |
| 29 | 0·883 | 52 | 0·776 | 75 | 0·689 |
| 30 | 0·878 | 53 | 0·770 | 76 | 0·686 |
| 31 | 0·872 | 54 | 0·766 | 77 | 0·682 |
| 32 | 0·867 | 55 | 0·762 | | |

# APPENDIX B.

## HYDROMETER TABLE FOR LIQUIDS HEAVIER THAN WATER.

| Degrees Baumé. | Degrees Twaddell. | Specific Gravity. | Degrees Baumé. | Degrees Twaddell. | Specific Gravity. |
|---|---|---|---|---|---|
| 1 | 1·4 | 1·007 | 34 | 61·6 | 1·308 |
| 2 | 2·8 | 1·014 | 35 | 64·0 | 1·320 |
| 3 | 4·4 | 1·022 | 36 | 66·4 | 1·332 |
| 4 | 5·8 | 1·029 | 37 | 69·0 | 1·345 |
| 5 | 7·4 | 1·037 | 38 | 71·4 | 1·357 |
| 6 | 9·0 | 1·045 | 39 | 74·0 | 1·370 |
| 7 | 10·2 | 1·052 | 40 | 76·6 | 1·383 |
| 8 | 12·0 | 1·060 | 41 | 79·4 | 1·397 |
| 9 | 13·4 | 1·067 | 42 | 82·0 | 1·410 |
| 10 | 15·0 | 1·075 | 43 | 84·8 | 1·424 |
| 11 | 16·6 | 1·083 | 44 | 87·6 | 1·438 |
| 12 | 18·2 | 1·091 | 45 | 90·6 | 1·453 |
| 13 | 20·0 | 1·100 | 46 | 93·6 | 1·468 |
| 14 | 21·6 | 1·108 | 47 | 96·6 | 1·483 |
| 15 | 23·2 | 1·116 | 48 | 99·6 | 1·498 |
| 16 | 25·0 | 1·125 | 49 | 103·0 | 1·515 |
| 17 | 26·8 | 1·134 | 50 | 106·0 | 1·530 |
| 18 | 28·4 | 1·142 | 51 | 109·2 | 1·546 |
| 19 | 30·4 | 1·152 | 52 | 112·6 | 1·563 |
| 20 | 32·4 | 1·162 | 54 | 116·0 | 1·580 |
| 21 | 34·2 | 1·171 | 55 | 123·0 | 1·615 |
| 22 | 36·0 | 1·180 | 56 | 127·0 | 1·635 |
| 23 | 38·0 | 1·190 | 57 | 130·4 | 1·650 |
| 24 | 40·0 | 1·200 | 58 | 134·2 | 1·671 |
| 25 | 42·0 | 1·210 | 59 | 138·2 | 1·691 |
| 26 | 44·0 | 1·220 | 60 | 142·0 | 1·710 |
| 27 | 46·2 | 1·231 | 61 | 146·4 | 1·732 |
| 28 | 48·2 | 1·241 | 62 | 150·0 | 1·753 |
| 29 | 50·4 | 1·252 | 63 | 155·0 | 1·775 |
| 30 | 52·6 | 1·263 | 64 | 159·0 | 1·795 |
| 31 | 54·8 | 1·274 | 65 | 164·0 | 1·820 |
| 32 | 57·0 | 1·285 | 66 | 168·4 | 1·842 |
| 33 | 59·4 | 1·297 | 67 | 173·0 | 1·865 |

To convert Twaddell degrees into actual specific gravity, multiply the number of degrees by 5 and prefix 1·; or if the degree is below 20, 1·0; thus 132° Twaddell is 132 × 5 = 660 = 1·660 specific gravity, and 13° Twaddell is 13 × 5 = 65 = 1·065 specific gravity. To reduce actual specific gravity to Twaddell degrees, divide the decimal figures by 5; thus 1·248 is 248 ÷ 5 = 49·6° Twaddell.

# APPENDIX C.

## COMPARISON OF TEMPERATURE DEGREES.

C = Celsius or Centigrade.   F = Fahrenheit.

| C. | F. | C. | F. | C. | F. | C. | F. | C. | F. |
|---|---|---|---|---|---|---|---|---|---|
| -17 | +1·4 | +7 | +44·6 | +31 | +87·8 | +55 | +131 | +79 | +174·2 |
| 16 | 3·2 | 8 | 46·6 | 32 | 89·6 | 56 | 132·8 | 80 | 176 |
| 15 | 5 | 9 | 48·2 | 33 | 91·4 | 57 | 134·6 | 81 | 177·8 |
| 14 | 6·8 | 10 | 50 | 34 | 93·2 | 58 | 136·4 | 82 | 179·6 |
| 13 | 8·6 | 11 | 51·8 | 35 | 95 | 59 | 138·2 | 83 | 181·4 |
| 12 | 10·4 | 12 | 53·6 | 36 | 96·8 | 60 | 140 | 84 | 183·2 |
| 11 | 12·2 | 13 | 55·4 | 37 | 98·6 | 61 | 141·8 | 85 | 185 |
| 10 | 14 | 14 | 57·2 | 38 | 100·4 | 62 | 143·6 | 86 | 186·8 |
| 9 | 15·8 | 15 | 59 | 39 | 102·2 | 63 | 145·4 | 87 | 188·6 |
| 8 | 17·6 | 16 | 60·8 | 40 | 104 | 64 | 147·2 | 88 | 190·4 |
| 7 | 19·4 | 17 | 62·6 | 41 | 105·8 | 65 | 149 | 89 | 192·2 |
| 6 | 21·2 | 18 | 64·4 | 42 | 107·6 | 66 | 150·8 | 90 | 194 |
| 5 | 23 | 19 | 66·2 | 43 | 109·4 | 67 | 152·6 | 91 | 195·8 |
| 4 | 24·8 | 20 | 68 | 44 | 111·2 | 68 | 154·4 | 92 | 197·6 |
| 3 | 26·6 | 21 | 69·8 | 45 | 113 | 69 | 156·2 | 93 | 199·4 |
| 2 | 28·4 | 22 | 71·6 | 46 | 114.8 | 70 | 158 | 94 | 201·2 |
| 1 | 30·2 | 23 | 73·6 | 47 | 116·6 | 71 | 159·8 | 95 | 203 |
| *0 | 32 | 24 | 75·2 | 48 | 118·4 | 72 | 161·6 | 96 | 204·8 |
| +1 | 33·8 | 25 | 77 | 49 | 120·2 | 73 | 163·4 | 97 | 206·6 |
| 2 | 35·6 | 26 | 78·8 | 50 | 122 | 74 | 165·2 | 98 | 208·4 |
| 3 | 37·4 | 27 | 80·6 | 51 | 123·8 | 75 | 167 | 99 | 210·2 |
| 4 | 39·2 | 28 | 82·4 | 52 | 125·6 | 76 | 168·8 | †100 | 212 |
| 5 | 41 | 29 | 84·2 | 53 | 127·4 | 77 | 170·6 | | |
| 6 | 42·8 | 30 | 86 | 54 | 129·2 | 78 | 172·4 | | |

## RULES FOR CONVERTING TEMPERATURES FROM ONE SCALE TO ANOTHER.

(*a*) *To Convert Centigrade into Fahrenheit Degrees.*—Multiply the degree by 9, divide the result by 5 and add 32. For example· 36° C. into F. :—

---

* Freezing point.    † Boiling point.

36° × 9 = 324. 324 ÷ 5 = 64·8.
64·8 + 32 = 96·8° F.

In the case of temperatures below the freezing point, 0° of the Centigrade scale, the rule is to multiply by 9, divide the result by 5, take the difference between the number so obtained and 32; if it be the larger number add the sign – to the result, if the smaller add the sign +. The following examples illustrate these rules:—

(1) – 8° C. to F., and (2) – 40° C. to F.
(1) 8 × 9 = 72. 72 ÷ 5 = 14·4. 32 – 14·4 = + 17·6° F.
(2) 40 × 9 = 360. 360 ÷ 5 = 72. 72 – 32 = – 40° F.

(*b*) *To Convert Fahrenheit Degrees into Centigrade Degrees.*—Subtract 32, multiply the result by 5, and divide this second result by 9.

Thus convert 72° F. into C. degrees.

72 – 32 = 40. 40 × 5 = 200. 200 ÷ 9 = 22·2° C.

When the temperatures are between 32° and 0° F., take the difference between 32 and the degree and proceed as before, adding a – sign to the result. For example, reduce 24° F. to C. degrees:—

32 – 24 = 8. 8 × 5 = 40. 40 ÷ 9 = 4·4 = – 4·4° F.

If below 0° F., add 32 to the degree, and proceed as before, adding a minus sign to the result. For example, reduce – 18° F. to C. degrees:—

18 + 32 = 50. 50 × 5 = 250. 250 ÷ 9 = 26·6. – 26·6° F.

# APPENDIX D.

## TABLES FOR CONVERTING FRENCH METRIC WEIGHTS AND MEASURES INTO ENGLISH WEIGHTS AND MEASURES.

### A.—WEIGHTS.

| French. | English. | | | French. | English. | | |
|---|---|---|---|---|---|---|---|
| Grammes. | Lb. | Oz. | Grains. | Grammes. | Lb. | Oz. | Grains. |
| 1 | — | — | 15·432 | 60 | — | 2 | 48·908 |
| 2 | — | — | 30·864 | 70 | — | 2¼ | 93·851 |
| 3 | — | — | 46·296 | 80 | — | 2 | 31·319 |
| 4 | — | — | 61·728 | 90 | — | 3 | 75·362 |
| 5 | — | — | 77·160 | 100 | — | 3½ | 9·930 |
| 6 | — | — | 92·592 | 200 | — | 7 | 19·860 |
| 7 | — | — | 108·024 | 300 | — | 10½ | 29·790 |
| 8 | — | 0¼ | 14·079 | 400 | — | 14 | 39·720 |
| 9 | — | 0¼ | 29·511 | 500 | 1 | 1½ | 49·650 |
| 10 | — | 0¼ | 44·943 | 600 | 1 | 5 | 59·580 |
| 20 | — | 0½ | 89·886 | 700 | 1 | 8½ | 69·510 |
| 30 | — | 1 | 24·456 | 800 | 1 | 12 | 79·440 |
| 40 | — | 1¼ | 70·397 | 900 | 1 | 15½ | 89·370 |
| 50 | — | 1¾ | 4·965 | 1000 | 2 | 3 | 99·300 |

1000 grammes = 1 kilo.
1000 kilos = 19 cwt. 2 qrs. 21 lb.
1 ton = 1016 kilos.
1 cwt. = 50·80 kilos.
1 qr. = 12·70 kilos.
1 lb. = 454 grammes.
1 oz. = 28·3 grammes.

To reduce ounces to grammes, multiply by 28·35.
To reduce grains to grammes, multiply by 0·0648.

## B.—LENGTH.

| French. | English. |
|---|---|
| 1 millimetre | = 0·0393 inch. |
| 2 „ | = 0·0787 „ |
| 3 „ | = 0·1181 „ |
| 4 „ | = 0·1574 „ |
| 5 „ | = 0·1968 „ |
| 6 „ | = 0·2362 „ |
| 7 „ | = 0·2756 „ |
| 8 „ | = 0·3160 „ |
| 9 „ | = 0·3543 „ |
| 10 „ | = 0·3937 „ |
| 25 „ | = 1 inch nearly. |
| 10 centimetre | = 4 inch nearly. |
| 20 „ | = 7·87 inch. |
| 30 „ | = 11·81 inch. |
| 40 „ | = 15·74 „ |
| 50 „ | = 19·68 „ |
| 60 „ | = 23·62 „ |
| 70 „ | = 27·56 „ |
| 80 „ | = 31·5 „ |
| 90 „ | = 35·43 „ |
| 100 „ | = 39·37 „ |
| 1 metre | = 39·3707 inches. |
| 1 „ | = 3·280 feet. |
| 1 „ | = 1·0936 yard. |
| 1 kilometre | = 1093·63 yards. |
| 1 „ | = 0·6214 mile. |

| English. | French. |
|---|---|
| 1 inch | = 25·39 millimetres. |
| 1 foot | = 30·479 centimetres. |
| 1 yard | = 0·9144 metre. |
| 1 mile | = 1·609 kilometres. |

To reduce centimetres to inches, multiply by 0·3937. To reduce inches to metres, multiply by 0·0254. To reduce inches to centimetres, multiply by 2·54.

## C.—CAPACITY.

| French. | | English. | | |
|---|---|---|---|---|
| 1 cubic centimetre (c.c.) | = | ·061 cubic inches. | | |
| 1 ,, ,, | = | ·0352 fluid oz. | = | ⅓ fluid drs. nearly. |
| 2 ,, ,, | = | ·0704 ,, | = | ⅔ ,, ,, |
| 3 ,, ,, | = | ·1156 ,, | = | 1 ,, ,, |
| 4 ,, ,, | = | ·1408 ,, | = | 1⅓ ,, ,, |
| 5 ,, ,, | = | ·1760 ,, | = | 1⅔ ,, ,, |
| 6 ,, ,, | = | ·2112 ,, | = | 1¾ ,, ,, |
| 7 ,, ,, | = | ·2464 ,, | = | 2 ,, ,, |
| 8 ,, ,, | = | ·2816 ,, | = | 2⅓ ,, ,, |
| 9 ,, ,, | = | ·3168 ,, | = | 2⅔ ,, ,, |
| 10 ,, ,, | = | ·352 ,, | = | 3 ,, ,, |
| 28 ,, ,, | = | 1 fluid oz. nearly. | | |
| 1 litre | = | 35·215 fluid oz. | = | 1·76 pint. |
| 2 litres | = | 70·430 ,, | = | 3·52 ,, |
| 3 ,, | = | 105·646 ,, | = | 5·28 ,, |
| 4 ,, | = | 140·861 ,, | = | 7·04 ,, |
| 5 ,, | = | 176·077 ,, | = | 8·80 ,, |
| 6 ,, | = | 211·292 ,, | = | 10·56 ,, |
| 7 ,, | = | 246·507 ,, | = | 12·32 ,, |
| 8 ,, | = | 281·723 ,, | = | 14·08 ,, |
| 9 ,, | = | 316·938 ,, | = | 15·84 ,, |
| 10 ,, | = | 352·154 ,, | = | 17·60 ,, |
| 20 ,, | = | 4 gallons, 1½ pints. | | |
| 30 ,, | = | 6 ,, 4¾ ,, | | |
| 40 ,, | = | 8 ,, 6½ ,, | | |
| 50 ,, | = | 11 ,, | | |
| 60 ,, | = | 13 ,, 1¾ ,, | | |
| 70 ,, | = | 15 ,, 3¼ ,, | | |
| 80 ,, | = | 17 ,, 4¾ ,, | | |
| 90 ,, | = | 19 ,, 6½ ,, | | |
| 100 ,, | = | 22 ,, | | |

| French. | | English. |
|---|---|---|
| 1 cubic metre | = | 35·316 cubic feet. |

| English. | French. |
|---|---|
| 1 cubic inch | = 16·386 cubic centimetres. |
| 1 cubic foot | = 28·315 litres. |
| 1 fluid drachm | = 3·55 cubic centimetres. |
| 1 fluid oz. | = 28·39 „ |
| 1 pint | = 567·9 „ |
| 1 quart | = 1·136 litre. |
| 1 gallon | = 4·548 litres. |

To reduce litres to gallons, multiply by 0·22. To reduce pints to cubic centimetres, multiply by 567·936. To reduce gallons to litres, multiply by 4·548.

# APPENDIX E.

## Table of the Elements, their Symbols, and Atomic Weights.

| Name. | Smybol. | Atomic Weight. | Name. | Symbol. | Atomic Weight. |
|---|---|---|---|---|---|
| 1. Aluminium | Al | 27·1 | 36. Nickel | Ni | 59 |
| 2. Antimony | Ab | 120 | 37. Niobium | Nb | 94·2 |
| 3. Arsenic | As | 75 | 38. Nitrogen | N | 14 |
| 4. Barium | Ba | 137 | 39. Osmium | Os | 192 |
| 5. Beryllium | Be | 9·1 | 40. Oxygen | O | 16 |
| 6. Bismuth | Bi | 208 | 41. Palladium | Pd | 106 |
| 7. Boron | B | 11 | 42. Phosphorus | P | 31 |
| 8. Bromine | Br | 80 | 43. Platinum | Pt | 194·8 |
| 9. Cadmium | Cd | 112·1 | 44. Potassium | K | 39·1 |
| 10. Caesium | Cs | 132·9 | 45. Rhodium | Rh | 103 |
| 11. Calcium | Ca | 40 | 46. Rubidium | Rb | 85·4 |
| 12. Carbon | C | 12 | 47. Ruthenium | Ru | 103·9 |
| 13. Cerium | Ce | 140·2 | 48. Samarium | Sa | 150 |
| 14. Chlorine | Cl | 35·5 | 49. Scandium | Sc | 44·1 |
| 15. Chromium | Cr | 52·5 | 50. Selenium | Se | 79·1 |
| 16. Cobalt | Co | 59 | 51. Silicon | Si | 28·4 |
| 17. Copper | Cu | 63·3 | 52. Silver | Ag | 108 |
| 18. Didymium | Di | 147 | 53. Sodium | Na | 23 |
| 19. Erbium | Er | 166 | 54. Strontium | Sr | 37·5 |
| 20. Fluorine | F | 19 | 55. Sulphur | S | 32 |
| 21. Gallium | Ga | 69·9 | 56. Tantalum | Ta | 129 |
| 22. Germanium | Ge | 72·3 | 57. Tellurium | Te | 125 |
| 23. Gold | Au | 197·2 | 58. Thallium | Tl | 204·1 |
| 24. Hydrogen | H | 1 | 59. Thorium | Th | 332·4 |
| 25. Indium | In | 113·7 | 60. Thulium | Tu | 171 |
| 26. Iodine | I | 127 | 61. Tin | Sn | 118 |
| 27. Iridium | Ir | 193·2 | 62. Titanium | Ti | 48·1 |
| 28. Iron | Fe | 56 | 63. Tungsten | W | 184 |
| 29. Lanthanum | La | 138·5 | 64. Uranium | U | 239·4 |
| 30. Lead | Pb | 207 | 65. Vanadium | V | 51·2 |
| 31. Lithium | Li | 7 | 66. Ytterbium | Yb | 173·2 |
| 32. Magnesium | Mg | 24 | 67. Yttrium | Y | 88·7 |
| 33. Manganese | Mn | 55 | 68. Zinc | Zn | 65 |
| 34. Mercury | Hg | 200 | 69. Zirconium | Zr | 90·7 |
| 35. Molybdenum | Mo | 95·9 | | | |

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